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[Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/ table/figure, etc, be stated on a fresh row. Information/comments should include reasons for comments, technical references and suggestions for modified wordings of the clause. **Comments through e-mail in MS WORD format to eetd@bis.gov.in shall be appreciated.**]

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Title: Draft National Lighting Code of India: Part 5 Interior Illumination/ Section 1 to Section 9 [First Revision of SP 72 (Part 5/Section 1 to Section 9)]

Name of the Commentator/ Organization: _____

Part 5 /Section 1 Industrial Lighting		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 2 Office Lighting		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 3 Lighting for Educational Facilities		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**

Part 5 /Section 4 Hospital Lighting		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 5 Hospitality Lighting		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 6 Lighting For Retail Premises		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 7 Lighting for Art & Museum		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**
Part 5 /Section 8 Lighting for Residential Area		

Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	Comments / Modified Wordings	Justification of Proposed Change
Part 5 /Section 9 Lighting for Places of Worship		
Clause No. with Para No. or Table No. or Figure No. commented (as applicable)	**Comments / Modified Wordings**	**Justification of Proposed Change**

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 1 Industrial Lighting

[First Revision of SP 72 (Part 5/Section 1)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49	**Last Date for Comments: 06-June-2024**

FOREWORD

The purpose of industrial lighting is to provide energy efficient illumination and to enhance visibility and productivity within a pleasant and safe environment. Human aspects of lighting is also now becoming an very important and crucial in Industrial lighting.

Industry encompasses seeing tasks, operating conditions and economic considerations of a wide range. Visual tasks may be extremely small or very large; dark or light; opaque, transparent or translucent; on specular or diffuse surfaces and may involve flat or contoured shapes. Lighting must be suitable for adequate visibility in developing raw materials into finished products. Physical hazards exist in manufacturing processes and therefore, lighting contributes to the safety factor in preventing accidents. The speed of operations may be such as to allow only minimum time for visual perception and, therefore, lighting must be a compensating factor to increase the speed of vision.

The design of a lighting system and selection of equipment may be influenced by many economic and energy related factors. Economic decisions in regard to the lighting system should not only be based on the initial and operating costs of the lighting, but also on the relationship of lighting costs

to other plant facilities and costs of labour. The lighting system should be a part of an overall planned environment.

Taking into consideration the increasing industrial activities in India, a large number of people have to work on tasks and processes of increasing intricacy and detail with working hours extending into the night, need has been felt for well-planned and efficient industrial lighting which could create easier seeing conditions and agreeable atmosphere.

1 SCOPE

1.1 This part and section of the code covers the principles and practice governing good lighting for various industrial premises. It recommends the levels of illumination and quality requirements to be achieved by general principles of lighting.

2 TERMINOLOGY

2.1 For the purpose of this section, the definitions given in Part 1 of this code and those given in IS 1885 (Part 16/Sec 1) shall apply.

3 REFERENCES

IS Number	*Title*
IS 2440:1975	Guide for daylighting of Buildings (second revision)
IS 3646 (Part 1): 1992	Code of practice for interior illumination: Part 1 General requirements and recommendations for working interiors (first revision)
IS 5572: 2009	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installations (Third revision)
IS 6060: 1971	Code of practice for daylighting of factory building
IS 10322(Part 1): 2014	Luminaires: Part 1 General requirements and tests

4 FACTORS OF GOOD INDUSTRIAL LIGHTNG

4.1 A good industrial lighting should take into account:

a) adequate quantity of illumination, and
b) good quality of illumination.

4.1.1 *Quantifying Illumination Level*

The desirable level of light (illuminance) for an installation depends primarily upon the seeing task, and the importance of speed and accuracy in performing the task.

Illuminance recommendations for industrial tasks are given in Table 3. In addition, in several instances industry representatives have established tables of single illuminance values which, in their opinion, can be used in preference to employing Table 3. However, illuminance values for specific operations can also be determined using illuminance categories of similar tasks and activities found in Table 3 and the application of the appropriate weighting factors. In either case, the values given are considered to be target maintained illuminance.

4.1.1.1 To ensure that a given illuminance will be maintained, it is necessary to design a system to give initially more light than the target value. In locations where dirt will collect very rapidly on luminaire surfaces and where adequate maintenance is not provided, the initial value should be even higher.

Where workers wear eye protective devices with occupationally required tinted lenses that materially reduce the light reaching the eye, the illuminance for individual tasks should be increased accordingly.

4.1.1.2 The utilization goal of a lighting system is to provide for optimal performance of a given task. A starting point will be the determination of relationship between illumination and performance, but the final recommendation has to take into consideration other factors such as avoidance of fatigue, physiological and psychological effects, economics, etc. Desirable criteria for determining the quantity of illumination are:

a) adequacy for preventing occupational eye-strain and the risk of accidental injury due to bad visibility;
b) adequacy for creating an agreeable luminous environment; and
c) adequacy for different satisfactory levels of visual performance, each standard being applicable to a particular range of visual task.

4.1.1.3 A general lighting system should be designed to provide a uniform distribution of light over the entire work area. Where work areas are close to walls, -such as work benches, the first row of luminaires should be located closer to wall or additional lighting should be provided over the particular work space.

4.1.1.4 Higher initial values shall be provided for the absorption of the light while designing lighting requirements.

4.1.2 *Quality of Illumination*

4.1.2.1 Quality of illumination pertains to the distribution of luminance in the visual environment. The term is used in a positive sense and implies that all luminances contribute favourably to visual performance, visual comfort, ease of seeing, safety and aesthetics for the specific visual task involved. Glare, diffusion, direction, uniformity, colour, luminance and luminance ratios all have a significant effect on visibility and the ability to see easily, accurately and quickly. Certain seeing tasks, such as discernment of fine details, require much more careful analysis and higher quality

illumination than other. Areas where the seeing tasks are severe and performed over long periods of time require much higher quality than where seeing tasks are casual or of relatively short duration.

Industrial installations of very poor quality are easily recognized as uncomfortable and are possibly hazardous. Unfortunately, moderate deficiencies are not readily detected, although the cumulative effect of even slightly glaring conditions can result in material loss of seeing efficiency and undue fatigue.

4.1.2.2 *Direct glare* — To reduce direct glare in industrial areas, the following steps should be taken:

a) Decrease the luminance of light sources or lighting equipment, or both;
b) Reduce the area of high luminance causing the glare condition;
c) Increase the angle between the glare source and the line of vision; and
d) Increase the luminance of the area surrounding the glare source and against which it is seen.

There is such a wide divergence of tasks and environmental conditions in industry that it may not be economically feasible to recommend a degree of quality which will satisfy all cases. The luminance control required depends on the task, length of time in which the task is performed, and the mounting height of the luminaires in production areas, luminaires within the normal field of view should be shielded to at least 25 degrees from the horizontal preferably to 45 degrees.

When glare is caused by the source of lighting within the field of view, whether daylight or electric, it is described as direct glare. Recommended maximum luminance ratio is given in the following table:

Table 1 Recommended Maximum Luminance Ratios

Sl. No	**Environmental Classification**	**A**	**B**	**C**
(1)	(2)	(3)	(4)	(5)
i)	Between tasks and adjacent darker surroundings	3 to 1	3 to 1	5 to 1
ii)	Between tasks and adjacent lighter surroundings	1 to 3	1 to 3	1 to 5
iii)	Between tasks and more remote darker surfaces	-	10 to 1	20 to 1
iv)	Between tasks and more remote lighter surfaces	-	1 to 10	1 to 20
v)	Between luminaires (or windows, skylights, etc) and surfaces adjacent to them	20 to 1	-	-
vi)	Anywhere within normal head of view	40 to 1	-	-

Classifications are-

a) Interior areas where reflectance of entire space can be controlled in line with recommendations for optimum seeing conditions.
b) Areas where reflectance of immediate work area can be controlled but control of remote surrounding is limited.
c) Areas (indoor and outdoor) where it is completely impractical to control reflectance and difficult to alter environmental conditions

Luminance ratio control is not practical. Luminance of light sources or lighting equipment, or both reduce the area of high luminance causing the glare condition, increase the angle between the glare source and the line of vision and increase the luminance of the area surrounding the glare source and against which it is seen.

Unshaded factory windows are frequent causes of direct glare. They may permit direct view of the sun, bright portions of the sky or bright adjacent buildings. These often constitute large areas of very high luminance in the normal field of view.

Luminaires that are too bright for their environment will produce glare: discomfort glare or disability glare, or both. The former produces visual discomfort without necessarily interfering with visual performance or visibility. Disability glare reduces both visibility and visual performance and is often accompanied by visual discomfort. To reduce direct glare, luminaires should be mounted as far as possible above the normal line of sight. They should be designed to limit both the luminance and the quantity of light emitted in the 45 to 85 degree zone because such light, likely to be well within the field of view, any interfere with vision. This precaution includes the use of supplementary lighting equipment.

4.1.2.3 *Luminance and luminance ratios—*

a) *Ratios*

The ability to see detail depends upon the contrast between the detail and its background. The greater the contrast, difference in luminance, the more readily the seeing task is performed. However, the eyes function most comfortably and more efficiently when the luminances within the remainder of the environment are relatively uniform. Therefore, all luminances in the field of view should be carefully controlled. The recommended procedure for planning brightness pattern and controlling glare is detailed in IS 3646 (Part 1).

b) To achieve the recommended luminance relationships, it is necessary to select the reflectance's of all finishes of the room surfaces and equipment as well as control the luminance distribution. The recommended reflectance values for industrial interiors and equipment are given in Table 2. Reflectance should be maintained as near as practical to recommended values.

Table 2 Reflectance Values

(*Clause* 3.1.2.3 a)

Sl. No	Surfaces	Reflectance percent
(1)	(2)	(3)
i)	Ceiling	80 to 90
ii)	Walls	40 to 60
iii)	Desks and bench tops, machines and equipment	25 to 45
iv)	Floors	Not less than 20

c) High reflectance surfaces are generally desirable to provide the recommended luminance relationships and high utilization of light. They also improve the appearance of the work space. It is also desirable that the background is slightly darker than the seeing task.

It is necessary to select the reflectance of all the finishes of the room surfaces and equipment as well as control the luminance distribution of the lighting equipment. High reflectance surfaces are generally desirable to provide the recommended luminance relationships and high utilization of light. They also improve the appearance of the work space.

In many industries machines are painted such that they present a completely harmonious environment from the standpoint of colour. It appears desirable to paint stationary and moving parts of machines with contrasting colours to reduce accident hazard by aiding identification.

d) *Reflected glare*— Reflected glare is caused by the reflection of high luminance light sources from shiny surfaces. In manufacturing processes this may be a particularly serious problem where critical seeing is involved with highly polished surfaces such as polished sheet metal, vernier scales, and critically machined metal surfaces.

Reflected glare can be minimized or eliminated by using light sources of low luminance or by orienting the work so that reflections are not directed in the normal line of vision. Supplementary lighting is a solution to such problems. Often it is desirable to use reflections from a large area, low luminance luminaire located over the work. In special cases it may be practical to reduce the specular reflection (and the resultant reflected glare) by changing the specular character of the offending surface.

4.1.2.4 *Distribution, diffusion and shadows* — Uniform horizontal illuminance (where the maximum and minimum level is not more than one sixth above or below the average level of the area) is frequently appropriate for specific industrial interiors where tasks are closely spaced and where there are similar tasks requiring the same amount of light. In such instances, uniformity permits flexibility of functions and equipment and assures more uniform luminances. Alternate areas of extreme luminance differences are undesirable because it tires the eyes to adjust to them.

Maintaining uniformity between contiguous areas which have significantly different visibility (and illumination) requirements might be wasteful of energy; for example, a storage area adjacent to a machine shop. In such instances, it is prudent to design and apply non uniform lighting between

those areas. It may be accomplished by using luminaires of different wattage and /or by adjusting the number of luminaires per unit area. Local lighting restricted to a small work area is unsatisfactory unless there is sufficient general illumination.

Harsh shadows should be avoided, but some shadow effect may be desirable to accentuate the depth and form of objects. There are a few specific visual tasks where clearly defined shadows improve visibility and such effects should be provided by supplementary lighting equipment arranged for the particular task.

4.1.2.5 *Colour quality of light* — For general seeing tasks in industrial areas, there appears to be no effect upon visual acuity by variations in colour of light. However, where colour discrimination and colour matching are a part of the work process, the light source selected should have the desired colour rendering properties.

Colour, of course, has an effect upon the appearance of the work space and upon the complexions of personnel. Therefore, the selection of the lighting system and the decorative scheme should be carefully coordinated.

4.1.2.6 *Veiling reflections* — Where seeing task details are specular, care should be taken to minimize veiling reflections which will decrease task visibility.

4.1.2.7 *Brightness consideration* — The eye adapts itself to the prevailing brightness of the surroundings. The apparent brightness of the various surfaces or objects will depend on this adaptation level. For instance, when a room interior is seen through an open door from outside with bright day light, it will appear gloomy. But on entering the room, after the eye has adapted, things will appear brighter. When a room is lit by daylight the eye has a fairly high adaptation level due to the bright sky seen through the window opening. Therefore, the parts of the room remote from the windows will appear gloomy even if the illumination in these parts in terms of hut is of the order normally recommended for the type of visual task. It is, therefore, necessary to brighten up these parts if a proper balance of brightness is to be restored which will create comfortable visual environment. This second consideration is at least as important as the first while determining the amount of light to be supplied by the supplementary lighting system. This requirement in some cases may result in having higher levels of illumination than required for the particular visual task involved or higher than the amenity level.

During night time since the entire area is illuminated to a level recommended for the satisfactory performance of the task carried out in the work area concerned, no additional problem of balance of brightness is involved provided the general requirement of avoidance of high brightness contrast by having suitably finished surfaces in the room is satisfied.

5 GENERAL CONSIDERATIONS OF DESIGN FOR LIGHTING INDUSTRIAL AREAS

5.1 The designer of an industrial lighting system should consider the following factors as the first and all important requirements of good planning.

a) Determine the quantity and quality of illumination desirable for the manufacturing processes involved.
b) Select lighting equipment that will provide the quantity and quality requirements by examining photometric characteristics, and mechanical performance that will meet installation, operating and actual maintenance conditions.
c) Select and arrange equipment so that it will be easy and practical to maintain.
d) Balance all of the energy management considerations and economic factors including initial, operating and maintenance costs, versus the quantity and quality requirements for optimum visual performance. The choice of the electric distribution system may affect over all economics.

5.2 Light Sources in Industrial Lighting

5.2.1 LED light sources are replaced all traditional lighting Different led mid to high power chips and even cov are used. In fact, LED here used as system with integrated driver, fittings of different optics. Refer Part 3 section 1 & 2 for details.

a) Type of application,
b) Atmospheric conditions of industrial interiors and/or exteriors,
c) Structural features,
d) Initial outlay,
e) Running cost, and
f) Ease of maintenance.

5.2.2 Apart from these, following factors such as luminous efficacy, lamp luminance, lamp life, lumen depreciation, colour temperature, colour rendering properties and ease of optical control, play a very vital role in the choice of light sources. All these aspects should be carefully considered while designing an industrial lighting scheme.

5.2.3 It may also be added here as broad guideline that for low and medium height ceiling in industry, tubular fluorescent lamps are applied for general uniform lighting whereas for high bays it is desired from lighting technique, economic and maintenance considerations for different Led system. Led hand lamps are used except few special hazards area still tungsten filament lamps used.

5.2.4 Today all lighting are led based lighting and retrofit led system are used for either in energy saving or DSM or ESCO lighting projects.

5.3 Luminaires for Industrial Lighting

The manner in which the light from the LED is controlled by the luminaire governs to a large extent the important effects of glare, shadows, distribution and diffusion. Luminaires are classified in accordance with the way in which they control the light. refer Part 4 section 1 & Part 4 Section 2 for details of luminaire.

Most industrial applications call for either the direct or semi direct types. Luminaires with upward components of light are preferred for most areas because an illuminated ceiling or upper structure reduces luminance ratios between luminaires and the background. The upward light reduces the "dungeon" effect of totally direct lighting and creates a more comfortable and more cheerful environment. Industrial luminaires for fluorescent, high intensity discharge and incandescent filament lamps are available with upward components. Good environmental luminance relationships can also often be achieved with totally direct lighting if their illuminance and room surface reflectance are high.

a) In selecting industrial luminaires, it will be noted that other factors leading to more comfortable installations include:
b) Light colored finishes on the outside of luminaires reducing luminance ratios between the outside of the luminaire and the inner reflecting surface and high source.
c) Higher mounting heights to raise luminaires out of the normal field of view.
d) Better shielding of the light source by deeper reflectors, cross baffles or louvres. This is particularly important with high wattage incandescent filament or high intensity discharge sources and the higher output fluorescent lamps.
e) Selecting light control material, such as specular or non-specular aluminium or prismatic configurated glass or plastic that can limit the luminaire luminance in the shielded zone.

Top openings in luminaires generally minimize dirt collection on the reflector and lamp by allowing an air draft path to move dirt particles upward and through the luminaire to the outer air. Therefore, ventilated types of luminaires have proven their ability to minimize maintenance of fluorescent, high intensity discharge, and incandescent filament types of luminaires. Gasketed dust tight luminaires are also effective in preventing dirt collection on reflector surfaces.

Special attention is required to be paid to the selection of luminaires for industrial interiors with highly corrosive atmosphere or fire and explosion hazard {see IS 10322(Part 1}. Luminaires made of corrosion resistant material specially designed for corrosive atmosphere are to be selected for chemical factories, fertilizer plants and other similar industries where corrosive fumes are present in the atmosphere. For industrial areas containing inflammable dust and gases, the choice of luminaire will be guided by relevant Indian Standard.

5.4 Luminaire for Direct Lighting

In Industrial Luminaires for direct lighting light distributions vary from wide to narrow.
The wide distribution types comprise porcelain enamelled reflectors and various other types of diffuse white reflecting surfaces. Aluminium, mirrored glass, prismatic glass, and other similar materials may also be used to provide a wide distribution when the reflector is designed with the

proper contour. This type of light distribution is advantageous in industrial applications where a large proportion of the seeing tasks are vertical or nearly vertical.

Narrow distributions are obtained with prismatic glass, mirrored glass and aluminium reflectors. This type of light distribution is useful where the mounting height is approximately equal to or greater than the width of the room or where high machinery and processing equipment necessitate directional control for efficient illumination between the equipment.

In making a choice between luminaires with wide and narrow distributions on the basis of desired horizontal illuminance, a comparison of coefficients of utilization for the actual room conditions involved will serve as a guide in selecting the most effective distribution. Care should be taken to use such coefficients based as close as practical to actual ceiling, wall and floor reflectance as well as actual room proportions.

If, however, it is desired to determine illuminance at specific points, then a point calculation method should be used to obtain accurate results. This is particularly true for high mounting heights.

5.5 Other Types of Luminaires for Direct Lighting

Where low reflected luminance is a necessity, low luminance luminaires with large area should be used. Such a luminaire may consist of a diffusing panel on a standard type of fluorescent lamp reflector or an indirect light hood. A completely luminous ceiling can also serve the purpose.

5.6 Luminaires for Semi Direct Lighting

This classification of distribution is useful in industrial areas because the upward component (10 to 40 percent) is particularly effective in creating more comfortable seeing conditions. Fluorescent and high intensity discharge lamp luminaires designed specifically for industrial application can give this distribution.

While the semi direct type of distribution has a sufficient upward component to illuminate the ceiling, the downward component of 90 to 60 percent of the output contributes to good illumination efficiency, particularly where ceiling obstructions may minimize the effectiveness of the indirect component.

5.7 Industrial Applications of Other Light Distribution Classifications

There are semi industrial applications, where a superior quality of diffused, low luminance illumination is required and where environmental conditions make such systems practical. An example of such applications includes the precision industries where a completely controlled environment is important, including lighting, air conditioning, and carefully planned decoration.

5.8 Lighting related to Structure of Industrial Premises

5.8.1 *Lighting of Factory Spaces with Skylights*

Where daylighting is given due consideration in the design of a building, the shape of the building is primarily determined by this requirement. The working area is also planned on the basis of daylighting. While planning the artificial lighting, the layout of the luminaires has to be related to the layout of the working area to obtain the most comfortable working. The lighting can be integrated with natural shape and structure of the building while still meeting the requirements of lighting effect on the working place, a better result. Close co-ordination between the architect and lighting engineer can result in a lighting installation which is in tune with the architectural form of the building.

5.8.2 *Lighting of Factory Spaces with Closed Ceiling*

In this type of construction there is very little dependence on daylighting. The artificial lighting has to be designed purely on the needs of the nature of work, layout of machinery, etc. Where false ceiling is provided, the luminaires may be recessed in the false ceiling for better aesthetics.

It is generally desired from the user's point of view that the luminaires should, as far as possible, be fixed to the existing members in the roof structure like the bottom members of the trusses or longitudinal tie members, etc. The luminaires have to be oriented according to the layout of the machinery to obtain most satisfactory seeing conditions. A layout decided on such a consideration may not coincide with the existing structural elements and additional members may have to be provided specifically for fixing the luminaires. An interesting development which takes care of this problem economically is the trunking system. The trunking, which is essentially metal channels with cover plates at the bottom, of standard lengths joined together, is run across the hall with suspensions at necessary intervals. Incidentally, this minimizes the number of suspension points compared to individually mounted luminaires each with two suspension pipes. The wiring is run through the trunking itself and the luminaires are attached to the trunking at the required locations.

5.8.3 *Highbay Lighting*

Generally high roofing is provided in heavy engineering industry, where overhead travelling crane is provided and/or fumes and smoke have to be carried off. The artificial lighting has to be located at a greater height in the roof structure to allow unobstructed movement of crane, etc. While for low and medium mounting height fluorescent lamp lighting is an immediate choice, for highbay lighting it is advantageous to use less number of high lumen output sources like the high wattage high pressure gas discharge lamps.

Today with the advent of LED system, many various high bay LED luminaire has been designed for energy efficient application and for creating ambience and Human centric lighting particularly in electronics factory. For more details, please refer Part 11 'Human Centric Lighting'.

6 FACTORS OF SPECIAL CONSIDERATION

6.1 Lighting and Space Conditioning

With the use of higher illuminance, it is often practical to combine the lighting, heating, cooling and atmospheric control requirements in an integrated system. The lighting system can often provide most of the heat energy during winter. When cooling is required, much of the lighting heat can be removed by the air exhaust system.

6.2 High Humidity or Corrosive Atmosphere and Hazardous Location Lighting

Enclosed gasketed luminaires are used in non-hazardous areas where atmospheres contain non inflammable dusts and vapours, or excessive dust. Enclosures protect the interior of the luminaire from conditions prevailing in the area. Steam processing, plating areas, wash and shower rooms, and other areas of unusually high humidity are typical areas that require enclosed luminaires. Severe corrosive conditions necessitate knowledge of the atmospheric content to permit selection of proper material for the luminaire.

Hazardous locations are areas where atmospheres contain inflammable dusts, vapours or gases in explosive concentrations. They are grouped on the basis of their hazardous characteristics, and all electrical equipment must be approved for use in specific classes and groups. Luminaires are available specifically designed to operate in these areas, which are classified as Class I, Class II and Class III locations (*see* IS 5572).

6.3 Abnormal Temperature Conditions

Low ambient temperatures must be recognized as existing in such areas as unheated heavy industrial plants, frozen food plants and cold storage warehouses. Luminaire Equipment should be selected to operate under such conditions and particular attention should be given to lamp starting and light output characteristics if fluorescent lamp is considered. With high intensity gas discharge lamp, temperature variation has practically no effect on light output, but the proper starting characteristics are a must. With incandescent filament lamp equipment, neither the starting nor the operations is a problem at low temperature.

Abnormally high temperatures may be common at truss height in foundries, steel mills, forge shops, etc. Caution should be observed in selecting luminaire for mounting in such locations. It is particularly important to consider the temperature limitations of fluorescent and high intensity gas discharge lamp ballasts under such conditions. Often ballast should be remotely located at a lower and cooler level or special luminaire suitable for high temperature should be used. The reduction in fluorescent lamp lumen output at high operating temperatures should be kept in mind.

6.4 Maintenance

Regular cleaning and prompt replacement of lamp outages is essential in any well operated industrial lighting system. It is important for the lighting designer to analyze luminaire construction and reflector finish and also to make provisions for maintenance access so the system can be properly serviced. Another point necessary to do the servicing is during the plant operating hours. Further details on maintenance, access methods and servicing suggestions are given in Part 10.

Special mention should be made of group replacement of the lamps and starters in case of fluorescent lamp luminaires. The desirability of group replacement is largely determined by lamp replacement costs and should be considered on its merit in each case.

7 SUPPLEMENTARY LIGHTING IN INDUSTRY

7.1 Difficult seeing tasks often require a specific amount or quality of lighting which cannot readily be obtained by general lighting methods. To solve such problems supplementary luminaires often are used to provide higher illuminance for small or restricted areas. Also, they are used to furnish a certain luminance, or colour to permit special aiming or positioning of light sources to produce or avoid highlights or shadows to best portray the details of the task.

Before supplementary lighting can be specified it is necessary to recognize the exact nature of the visual task and to understand its light reflecting or transmitting characteristics. An improvement in the visibility of the task will depend upon one or more of the four fundamental visibility factors—luminance, contrast, size and time. Thus, in analyzing the problem, the engineer may find that seeing difficulty is caused by insufficient luminance, poor contrast (veiling reflections), small size, or that task motion is too fast for existing seeing conditions.

The planning of supplementary lighting also entails consideration of the visual comfort of both those workers who benefit directly and those who are in the immediate area. Supplementary equipment must be carefully shielded to prevent glare for the user and his associates. Luminance ratios should be carefully controlled. Ratios between task and immediate surroundings should be limited as far as possible. To attain these limits it is necessary to coordinate the design of supplementary and general lighting.

8 PORTABLE LUMINAIRES

Wherever possible, luminaires should be permanently mounted in the location to produce the best lighting effect. Adjustable arms and swivels will often adapt the luminaires to required flexibility. Portable equipment, however, can be used to good advantage where it must be moved in and around movable machines or objects such as in airplane assembly, garages, or where internal surfaces must be viewed. The luminaires must be mechanically and electrically rugged to withstand possible rough handling. Lamps should be guarded and of the rough service type. Guards or other means should protect the user from excessive heat. Precautions should be taken to prevent electrical shock.

9 CLASSIFICATION OF VISUAL TASKS AND LIGHTING TECHNIQUES

9.1 Visual tasks are unlimited in number, but can be classified according to certain common characteristics. Classification is made according to their physical and light controlling characteristics and suggests lighting techniques for good visual perception.

It should be noted that the classification of visual tasks is based on the prime and fundamental visual task characteristics and not on the general application.

10 SPECIAL EFFECTS AND TECHNIQUES

10.1 Colour as a part of the seeing task can be very effectively used to improve contrast. While black and white are the most desirable combinations for continual tasks such as the reading of a book, it has been found that certain colour combinations have a greater attention value. Black on yellow is most legible and the next combinations in order of preference are green on white, red on white, blue on white, white on blue, and finally black on white.

It is sometimes necessary to inspect and study moving parts while they are in operation. This can be done with stroboscopic illumination which can be adjusted to "stop" or "slow up" the motion of constant speed rotating and reciprocating machinery. Stroboscopic lamps give flashes of light at controllable intervals (frequencies). Their flashing can be so timed that when the flash occurs an object with rotating or reciprocating motion is always in exactly the same position and appears to stand still.

11 DAYLIGHTING

11.1 Most people prefer to work in buildings having good daylighting. One of the characteristics of daylight which gives it this appeal is the constant change both in quality and quantity, creating interest and avoiding monotony. This variation is taken into account when planning a scheme to ensure that at no time will the illumination over the working area be less than that recommended for the particular visual task. In some buildings it will be possible to achieve this by natural lighting alone, but in other build in especially those located in obstructed city areas, it will be necessary to supplement the natural lighting by artificial lighting designed to operate permanently during day time; this should be properly coordinated with natural lighting as recommended in IS 3646 (Part 1). For detailed aspects of daylighting, reference may be made to IS 2440 and IS 6060.

11.2 The uniformity of illumination will depend on the design of the fenestration. Since this is part of the overall design of the building many factors come into picture. Generally there appears to be greater scope and freedom in industrial buildings for providing window arrangements which will give the desired day lighting conditions. Industrial buildings are generally located in unobstructed areas where there are sufficient open spaces all around, they have mostly one storey so that there is possibility of having skylights or windows in roofing, as for example, saw tooth roofing and monitor windows. The heights of the buildings are also enough to have a satisfactory spacing to height ratio of the windows.

12 PERMANENT SUPPLEMENTARY ARTIFICIAL LIGHTING (PSALI)

12.1 This refers to artificial lighting provided for use in daytime to supplement natural daylight.

12.2 The need for providing PASLI in buildings arises due to two reasons:

a) Due to various reasons adequate daylighting over the whole working area may not be available.
b) To create acceptable brightness levels on the various surfaces in the working interior.

For areas where the depths of the rooms are much more than the height of the room and windows may be available at one or two sides only, it is necessary to bring up the lighting to a level necessary for the task. At the darker zones, supplementary lighting is required.

13 RECOMMENDED ILLUMINANCES

13.1 Recommended illuminances should be graded according to the difficulty of the visual task. These values should be maintained in service through proper cleaning and revamping of luminaire, the cleaning of windows, and the maintenance of reflectance values of the room surfaces. Initial values shall be greater from the artificial lighting system by a percentage sufficient to compensate for the normal depreciation expected in service. An industry may also have an office or a conference room and for lighting of these spaces, the illumination values as given under the head 'Offices, Schools and Public Buildings' in IS 3646 (Part 1) shall apply. The recommended illuminance and limiting values of glare index for industrial buildings and processes are given in Table 3.

13.2 It is not a simple matter to specify suitable intensity levels if these are to be based upon sound reasoning. Since there is no distinct threshold level of illumination below which the performance of particular visual task is greatly impeded, some compromise has to be sought between an ideal level and one which is obviously inadequate. Generally, a recommended level is arrived at after being carefully weighed in the relation it bears to the eyesight, the visual task, the environment, and the economics involved. Any specification is, therefore, always open to a great deal of controversy. It may, however, be summarized that any of the above recommended illuminances could serve chiefly as a guide to good practices. It is not always sufficient to provide just enough light and leave it at that. Adequate illumination will benefit people with normal sight, but the benefit will be far greater to those with faulty vision. For example, elderly people require higher illumination values for the same facility of seeing as young people [see also IS 3646 (Part 1)]

13.3 In any lighting arrangement the required illuminance could be achieved through a combined usage of the natural daylighting and the artificial lighting. The object of designing artificial lighting specifically to supplement the available natural light is to provide light which satisfies the recommendations of both quantity and quality in all parts of 'the room or building, while at the same time preserving the sense that the lighting is predominately natural [see also IS 3646 (Part 1)].

Table 3 Recommended Values of Illumination and Limiting Values of Glare Index

(*Clause* 12.1)

Sl. No	Industrial Buildings and Processes	Average Illumination (lux)	Limiting Glare Index
(1)		(2)	(3)
i)	*General Factory Areas*		
	a) Canteens	150	-
	b) Cloakrooms	100	-
	c) Entrances, corridors, stairs	100	-
ii)	*Factory Outdoor Areas*		
	Stockyards, main entrances, exit roads, car parks, internal factory roads	20	-
iii)	*Aircraft Factories and Maintenance Hangers*		
	a) Stock parts productions	450	25
	b) Drilling, riveting, screw fastening, sheet aluminium layout and template work, wing sections, cowling welding, sub-assembly, final assembly, inspection	300	25
	c) Maintenance and repairs (hangers)	300	25
iv)	*Assembly Shops*		
	a) Rough work, for example, frame assembly, assembly of heavy machinery	150	28
	b) Medium work, for example, machined parts, engine assembly, vehicle body assembly	300	25
	c) Fine work, for example, radio and telephone equipment, typewriter and office machinery	700	22
	d) Very fine work, for example, assembly of very small precision mechanisms, instruments	1500 [1)]	19
v)	*Bakeries*		
	a) Mixing and make-up rooms, oven rooms, oven rooms, wrapping rooms	150	25
	b) Decorating and icing	200	25
vi)	*Boiler Houses (Industrial)*		
	a) Boiler fronts and operating areas	100	-
	b) Boiler rooms:		
	i) Boiler fronts and operating areas	100 [2)]	-
	ii) other areas	20 to 25	-
	c) Outdoor plants:		
	i) Catwalks	20	-
	ii) Platforms	50	-
vii)	*Bookbinding*		
	a) Pasting, punching and stitching	200	25

	b) Binding and folding-miscellaneous machines	300	22
	c) Finishing, blocking and inlaying	300	22
viii)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
ix)	*Boot and Shoe Factories*		
	a) Sorting and grading	1000 [3)]	19
	b) Clicking and closing, preparatory operations	700	22
	c) Cutting table and presses, stitching	1000	22
	d) Bottom stock preparation, lasting and bottoming, finishing	700	22
	e) Shoe rooms	700	22
x)	*Breweries and Distilleries*		
	a) General working areas	150	25
	b) Brew house, bottling and canning plants	200	25
	c) Bottle *inspection*	Special lighting	--
xi)	*Canning and Preserving Factories*		
	a) Inspection of beans, rice, barley, etc	450	22
	b) Preparation: Kettle areas, mechanical cleaning, dicing,	300	25
	trimming	200	25
	c) Canned and bottled goods: Retorts	300	25
	d) High speed labelliig lines	450	-
	e) Can inspection		
xii)	*Carpet Factories*		
	a) Winding, beaming	200	25
	b) Designing, jacquard card cutting, setting pattern, tufting,	300	22
	topping, cutting, hemming, fringing		
	c) Weaving, mending, inspection	450	22
xiii)	*Ceramics (see Pottery and Clay Products)*	--	--
xiv)	*Chemical Works*		
	a) Hand furnaces, boiling tanks, stationery driers,	150	28
	stationery or gravity crystallizers, mechanical		
	driers, evaporators, filtration plants, mechanical		
	crystallizing bleaching, extractors, percolators,		
	nitrators, electrolytic cells		
	b) Controls, gauges, values; etc	100 [2)]	--
	c) Control rooms:		
	i) Vertical control panels	200 to 300	19
	ii) Control desks	300	19
xv)	*Chocolate and Confectionery Factories*		
	a) Mixing, blending, boiling	150	28
	b) Chocolate husking, winnowing, fat extraction,	200	25
	crushing and refining, feeding, bean cleaning,		
	sorting, milling, cream making		
	c) Hand decorating, inspection, wrapping, packing	300	22

xvi)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
xvii)	*Clothing Factories*		
	a) Matching-up	450 [3)]	19
	b) Cutting, sewing:		
	i) Light	300	22
	ii) Medium	450	22
	iii) Dark	700	22
	iv) Pressing	300	22
	c) Inspection:		
	i) Light	450	19
	ii) Medium	1000	19
	iii) Dark	1500	19
	d) Hand Tailoring:		
	i) Light	450	19
	ii) Medium	1000	19
	iii) Dark	1500	19
xviii)	*Collieries (Surface Buildings)*		
	a) Coal preparation plant:		
	i) Working areas	150	-
	ii) Other areas	100	-
	iii) Picking belt,	300	-
	iv) Winding houses	150	-
	b) Lamp rooms:		
	i) Main areas	100	-
	ii) Repair sections	150	-
	iii) Weigh cabins	150	-
	c) Fan houses	100	-
xix)	*Dairies*		
	a) General working areas	200 [4)]	25
	b) Bottte inspection	Special lighting	-
	c) Bottle filling	450	25
xx)	*Die Sinking*		
	a) General	300	-
	b) Fine	1000	19
xxi)	*Dye Works*		
	a) Reception, ‘grey’ perching	700	-
	b) Wet processes	150 [5)]	28
	c) Dry process	200 [5)]	28

	d) Dyers' offices	700 [3)]	19
	e) Final perching	2000 [3)]	-
xxii)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
xxiii)	*Electricity Generating Stations: Indoor locations*		
	a) Turbine halls	200	25
	b) Auxiliary equipment; battery rooms, blowers, auxiliary generators, switchgear and transformer chambers	100	-
	c) Boiler houses (including operating floors) platforms, coal conveyors, pulverizes, feeders, precipitators, soot and slag blowers	70 to 100	-
	d) Boiler house and turbine house	100	-
	e) Basements	70	-
	f) Conveyor houses, conveyor gentries, junction towers	70 to 100	-
	g) Control rooms:		
	i) Vertical control panels	200 to 300	19
	ii) Control desks	300	19
	iii) Rear of control panels	150	19
	iv) Switch houses	150	25
	h) Nuclear reactors and steam raising plants:		
	i) Reactor areas, boilers, galleries	150	25
	ii) Gas circulator bays	150	25
	iii) Reactor charge/discharge face	200	25
xxiv)	*Electricity Generating Stations* : *Outdoor Locations*		
	a) Coal unloading areas	20	-
	b) Coal storage areas	20	-
	c) Conveyors	50	-
	d) Fuel oil delivery headers	50	-
	e) Oil storage tanks	50	-
	f) Catwalks	50	-
	g) Platforms, boiler and turbine decks	50	-
	h) Transformers and outdoor switchgear	100	-
xxv)	*Engraving*		
	a) Hand	1000	19
	b) Machine (*see* Die Sinking)	-	-
xxvi)	*Farm Buildings (Dairies)*		
	a) Boiler houses	50	-
	b) Milk rooms	150	25
	c) Washing and sterilizing rooms	150	25
	d) Stables	50	-
	e) Milking parlours	150	25
xxvii)	*Flour Mills*		
	a) Roller, purifier, silks and packing floors	150	25
	b) Wetting tables	300	25

xxviii)	*Forges* (General)	150	28
xxix)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
xxx)	*Foundries*		
	a) Charging floors; tumbling cleaning, pouring, shaking out, rough moulding and rough core making	150	25
	b) Fine moulding and core making, inspection	300	25
xxxi)	*Garages*		
	a) Parking areas (interior)	70	28
	b) Washing and polishing, greasing, general servicing, pits	150	28
	c) Repairs	300	25
xxxii)	*Gas Work*		
	a) Retort houses, oil gas plants, water gas plants, purifiers, coke screening and coke handling plants (indoor)	30 to 50 [6)]	28
	b) Governor-, meter-, compressor-, booster- and exhauster-houses	100	25
	c) Open type plants:		
	i) Catwalks	20 [6)]	-
	ii) Platforms	50 [6)]	-
xxxiii)	*Gauge and Tool Rooms (General)*	700 [7)]	19
xxxiv)	*Glass Works and Processes*		
	a) Furnace rooms, bending, annealing lehrs	100	28
	b) Mixing rooms, forming (blowing, drawing, pressing, rolling)	150	28
	c) Cutting to size, grinding, polishing, toughening	200	25
	d) Finishing (bevelling, decorating, etching, silvering)	300	22
	e) Brilliant cutting	700	19
	f) Inspection:		
	i) General	200	19
	ii) Fine	700	19
xxxv)	*Glove Making*		
	a) Pressing, knitting, sorting, cutting	300	22
	b) Sewing:		
	i) Light	300	22
	ii) Medium	450	22
	iii) Dark	700	22
	c) Inspection:		
	i) Light	450	19
	ii) Medium	1000	19
	iii) Dark	1500	19

xxxvi)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
xxxvii)	*Hat Making*		
	a). Stiffening, braiding, cleaning, refining, forming, sizing, pouncing, flanging, ironing	150	22
	b) Sewing:		
	i) Light	300	22
	ii) Medium	450	22
	iii) Dark	700	22
xxxviii)	*Hosiery and Knitwear*		
	a) Circular and flat knitting machines universal winders, cutting out, folding and pressing	300	22
	b) Lock stitch and over locking machines:		
	i) Light	300	22
	ii) Medium	450	22
	iii) Dark	700	22
	c) Mending	1500	19
	d) Examining, finishing, light, medium and dark	700	19
	e) Linking or running on	450	19
xxxix)	*Inspection Shops (Engineering)*		
	a) Rough work, for example, counting, rough checking of stock parts etc.	150	28
	b) Medium work, for example, 'Go' and 'No-go' gauges, sub-assemblies	300	25
	c) Fine work, for example, radio and telecommunication equipment, calibrated scales, precision mechanisms, instruments	700	22
	d) Very fine work, for example, gauging and inspection of small intricate parts	1500	19
	e) Minute work very small instruments	3000 [1)]	10
xl)	*Iron and Steel works*		
	a) Marshalling and outdoor stockyards	10 to 20	-
	b) Stairs, gangways, basements, quarries, loading docks	100	-
	c) Slab yards, melting shops, ingot stripping soaking pits, blast furnace working areas, picking and cleaning lines, mechanical plants, pump houses	100	28
	d) Mould preparation, rolling and wire mills, mill motor rooms, power and blower houses	150	28
	e) Slab inspection and conditioning, cold strip mills, sheet and plate finishing, tinning, galvanizing, machine and roll shops	200	28
	f) Plate inspection	300	-
	g) Tinplate inspection	Special lighting	-

xli)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
xlii)	*Jewellery and Watch making*		
	a) Fine processes	700 [1)]	19
	b) Minute processes	3000 [1)]	10
	c) Gem cutting, polishing, setting	1500 [8)]	-
xliii)	*Laboratories and Test Rooms*		
	a) General laboratories, balance rooms	300	19
	b) Electrical and instrument laboratories	450	19
xliv)	*Laundries and Dry-cleaning Works*		
	a) Receiving, sorting, washing, drying, ironing (calendaring), dispatch	200	25
	b) Dry-cleaning, bulk machine work	200	25
	c) Fine hand ironing, pressing, inspection, mending, spotting	300	25
xlv)	*Leather Dressing*		
	a) Vats, cleaning, tanning, stretching, cutting, flashing and stuffing	150	28
	b) Finishing, staking, splitting and stating	200	28
xlvi)	*Leather working*		
	a) Pressing and glazing	450	22
	b) Cutting, scarfing, sewing	700	22
	c) Grading and matching	1000 [3)]	19
xlvii)	*Machines and Fitting Shops*		
	a) Rough bench and machine work	150	28
	b) Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	300	25
	c) Fine bench and machine work, fine automatic machines, medium grinding, fine bulling and polishing	700	22
xlviii)	*Motor Vehicle Plants*		
	a) Sub-assemblies, chassis and car assembly	300	25
	b) Final inspection	450	25
	c) Trim shops, body assembly, sub-assemblies	300	25
	d) Spray booths	450	-
xlix)	*Paint Works*		
	a) General automatic processes	200	25
	b) Special batch mixing	450	22
	c) Colour matching	700 [3)]	19
l)	*Paint Shops and Spraying Booths*		
	a) Dipping, tiring, rough spraying	150	25
	b) Rubbing, ordinary painting, spraying and finishing	300	25
	c) Fine painting, spraying and finishing	450	25
	d) Retouching and matching	700 [3)]	19

li)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
lii)	*Paper Works*		
	a) Paper and board making:		
	i) Machine houses, calendaring, pulp mills, preparation plants, cutting, finishing, trimming	200	25
	ii) inspection and sorting (over hauling)	300	22
	b) Paper converting processes:		
	i) Corrugated board, cartons, containers and paper sack manufacture, coating and laminating processes	200	25
	ii) Associated printing	300	25
liii)	*Pharmaceuticals and Fine Chemical Works*		
	a) Raw material storage	200	28
	b) Control laboratories and testing	300	19
	c) Pharmaceuticals manufacturing: grinding, granulating, mixing and drying, tableting, sterilizing and washing, preparation of solutions and filling, labelling, capping, cartooning and wrapping, inspection	300	25
	d) Fine chemical manufacture:		
	i) Plant processing	200	25
	ii) Fine chemical finishing	300	25
liv)	*Plastic works*		
	a) Manufacture (see Chemical Works)	-	-
	b) Processing:		
	i) Calendaring, extrusion	300	25
	ii) Moulding-compression, injection	200	25
	c) Sheet fabrication:		
	i) Shaping	200	25
	ii) Trimming, matching, polishing	300	25
	iii) Cementing	200	25
lv)	*Plating Shops*		
	a) Vat and baths, buffing, polishing, burnishing	150	25
	b) Final buffing and polishing	Special lighting	-
lvi)	*Pottery and Clay Products*		
	a) Grinding, filter pressing, kiln rooms, moulding, pressing, cleaning, trimming, glazing, firing etc.	150	28
	b) Enamelling, colouring, decorating	450 [3)]	19

lvii)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
lviii)	*Printing Works*		
	a) Type foundries:		
	i) Matrix making, dressing type, hand and machine casting	200	25
	ii) Front assembly, sorting	450	22
	b) Printing plants:		
	i) Machine composition, imposing stones	200	25
	ii) Presses	300	25
	iii) Composing room	450	19
	iv) Proof reading	300	19
	c) Electrotyping:		
	i)Block-making,electroplating,washing,backing	200	25
	ii) Moulding, finishing, routing	300	25
	d) Photo-engraving:		
	i) Block-making, etching, masking	200	25
	ii) finishing, routing	300	25
	e) Colour printing : Inspection area	700 [3)]	19
lix)	*Rubber Processing*		
	a) Fabric preparation creels	200	25
	b) Dipping, moulding, compounding calendars	150	25
	c) Tyre and tube making	200	25
lx)	*Sheet Metal Works*		
	a) Bench work, scribing, pressing, punching, shearing, stamping, spinning, folding	200	25
	b) Sheet inspection	Special lighting	-
lxi)	*Soap Factories*		
	a) Kettle houses and ancillaries, glycerin evaporation and distillation, continuous indoor soap making, plants:		
	i) General areas	150	25
	ii) Control panels	200 to 300	25
	b) Batch or continuous soap cooling, cutting and drying, soap milling, plodding:		
	i) General areas	150	25
	ii) Control panels, key equipment	200 to 300	25
	c) Soap stamping, wrapping and packing, granules making, granules storage and handling. filling and packing granules:		
	i) General areas	150	25
	ii) Control panels, machines	200 to 300	25
	d) Edible products processing and packing	200	25
lxii)	*Structural Steel Fabrication Plants*		
	a) General	150	28

	b) Marking off	300	28
lxiii)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
lxiv)	*Textile Mills (Cotton or Linen)*		
	a) Bale breaking, blowing, carding, roving, slubbing, spinning (ordinary counts), winding, heckling, spreading, cabling	150	25
	b) Warping, slashing, dressing and dyeing, doubling (fancy), spinning (fine counts)	200	25
	c) Healding (drawing-in)	700	-
	d) Weaving:		
	i) Patterned cloths, fine counts dark	700	19
	ii) Patterned cloths, fine counts light	300	19
	iii) Plain 'grey' cloth	200	19
	e) Cloth inspection	700 [3)]	-
lxv)	*Textile Mills (Silk or Synthetics)*		
	a)Soaking, fugitive tinting conditioning, setting of twist	200	25
	b) Spinning	450	25
	c) Winding, twisting, rewinding and coning, quilting, slashing :		
	i) Light thread	200	25
	ii) Dark thread	300	25
	d) Warping	300	25
	e) Healding (drawing-in)	700	-
	f) Weaving	700	19
	g) Inspection	1000 [3)]	19
lxvi)	*Textile Mills (Woollen)*		
	a) Scouring, carbonizing, teasing, preparing, raising, brushing, pressing, back-washing, gilling, crabbing and blowing	150	25
	b) Blending, carding, combing (white), tentering, drying, cropping	200	25
	c)Spinning, roving, winding, warping, combing (coloured), twisting	450	25
	d) Healding (drawing-in)	700	-
	e) Weaving:		
	i) Fine worsteds	700	19
	ii) Medium worsteds, fine woolens	450	19
	iii) Heavy woolens	300	19
	f) Burling and mending	700	19
	g) Perching:		
	i) Grey	700	-
	ii) Final	2000 [3)]	-

lxvii)	**Industrial Buildings and Processes**	**Average Illumination (lux)**	**Limiting Glare Index**
lxviii)	*Textile Mills (Jute)*		
	a) Weaving, spinning, flat, jacquard carpet looms, cop winding	200	25
	b) Yarn calendar	150	25
lxix)	*Tobacco Factories*		
	All processes	300 [9)]	22
lxx)	*Upholstering*		
	Furniture and vehicles	300	22
lxxi)	*Warehouses and Bulk Stores*		
	a) Large material, loading bays	100	28
	b) Small material, racks	150	25
	c) Packing and dispatch	150	25
lxxii)	*Welding and Soldering*		
	a) Gas and arc welding, rough spot welding	150	28
	b) Medium soldering, brazing and spot welding, for example, domestic hardware	300	25
	c) Fine soldering and spot welding, for example, instruments, radio set assembly	700	22
	d) Very fine soldering and spot welding, for example, radio valves	150	19
lxxiii)	*Woodworking Shops*		
	a) Rough sawing, and bench work	150	22
	b) Sizing, planning, rough sanding, medium machine and bench work, gluing, veneering, cooperage	200	22
	c) Fine bench and machine work, fine sanding and finishing	300	22

1) Optical aids should be used where necessary.
2) Supplementary local lighting may be required for gauge glasses and instrument panels.
3) Special attention should be paid to the colour quality of the light.
4) Supplementary local lighting may be required for sight glasses.
5) Supplementary local lighting should be used where necessary.
6) Supplementary local lighting should be used at important points.
7) Supplementary local lighting and optical aids should be used where necessary.
8) Special attention to colour quality of light may be necessary.
9) Special attention should be paid to the colour quality of the light in all processing areas.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 2 Office Lighting

[First Revision of SP 72 (Part 5/Section 2)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49 **Last Date for Comments: 06-June-2024**

FOREWORD

Over the years, lots of changes have taken place in office configurations and thus offices today are perceived as open offices/workstations with one chamber/close space reserved for the team leader/ unit head. This is to accommodate more people within the same space and more transparency in working of the employees. Further, significant space is required for Office equipment like Desktops, Printers, photocopier etc. and accordingly lighting requirements have also undergone a vast change.

Offices function with people who carry out many activities. These activities require many tasks to be performed which involve focus on a task, working for long hours, meeting with people from different work spheres, relaxing in between the tasks etc. The function of lighting therefore increases many folds. It does not remain merely a means of removing darkness so that people can see in closed spaces and carry out activities requiring focused attention but performs many other functions as well. Thus, besides providing illumination as per standards, lighting also works as a mood elevator, provides a feeling of comfort, supports people's circadian rhythm, removes irritation by providing a glare free environment, enhances the beauty of the interior features etc.

Further, Innovations and Energy conservation have also brought changes in the way lighting is perceived today. Accordingly lighting design is dependent on a host of factors and not merely on lux level on the working plane as per prescribed Standards other than general space lighting. In addition, office spaces have additional spaces reserved for Conference Room/Presentation room & visitor room/Lounge. The conference room generally has a round or rectangular table with one wall used as a screen. This space requires general lighting as well as dimmable lighting during presentations. Since the facility of conference rooms is used only during meetings/presentations, lighting controls may be incorporated in the lighting design so as to make the general lighting off during non-utilization hours.

Apart from the above, office lighting has also to cater for the people of every age group including visitors, lit every corner of the space without causing glare besides being the style statement of the particular office.

1 SCOPE

This section of the code covers the principal and practices governing good lighting of offices. It recommends the levels of illumination to be achieved by general principals of lighting.

This section does not include extensive area coverage. The general aspects of interior lighting including assessment of glare are dealt within IS 3646 (Part 1).

2 TERMINOLOGY

The definitions of the terms used in this section are given in Part 1 of this code.

3 NORMATIVE REFERENCE

The following Indian Standards are necessary adjuncts to this Standard.

IS No./ Other Standards	*Title*
IS 3646 (Part 1):1992	Code of practice for interior illumination: Part 1 general requirements and recommendations or working interiors (first revision)
CIE S 017:2020	International Lighting Vocabulary, second edition
IECC 2021	International Energy Conservation Code

4 BASIC LIGHTING REQUIREMENT OF OFFICES

Office Lighting Requirement can be broadly met in three ways:

a) General Lighting
b) Task Lighting and
c) Emergency Lighting

4.1 General Lighting

An evenly set illumination throughout the workplace is known as General Lighting. This is very essential to provide the perception of absence of darkness. This can be achieved by luminaires placed in the ceiling to throw uniform illumination in the space below them. Besides giving a perception of bright light, it also helps in general movement and seeing the objects placed in the workspace to avoid collision.

4.2 Task Lighting

Task lighting is to provide lighting on a specific object or surface and helps greatly in saving the energy. The purpose of task lighting is to focus light at a specific area to help accomplish a specific task. For instance, in a drawing office, task lighting will focus on the drawing sheet so that all finer details can be seen by the draftsman. This lighting therefore needs to be provided by spotlight or desk light.

4.3 Emergency Lighting

Emergency lighting is an essential lighting requirement in any space. The main purpose of this lighting is to provide a backup in case of power failure and for safe evacuation of people from the confined office spaces in case of prolonged power failure or during an emergency when fire breaks out or there is earthquake. This lighting should turn on automatically in the event of mains power failure.

5 KEY FACTORS IN THE DESIGN OF OFFICE LIGHTING

Following are the key factors to be considered in any lighting design**:**

5.1 Human Needs

Human Centric: The changing color temperature should be suited to circadian rhythm. It means the color temperature of light should suit the time of the day so that humans can perform the task without having the feeling of going against the natural cycle. The lighting should also be glare free so as not to be irritating, uniform and without shadow so as to be fatigue free not damaging to eyes.

5.2 Efficiency Needs

The light source should give luminous efficacy as high as possible. Besides the system efficacy of the luminaire should also be high. In other words, the lighting system selected should consume least power.

5.3 Control Needs

Lighting controls should be integrated to minimize the energy wastage.

5.4 Quality Needs

Lighting should be glare free, optimized for computer screen work and set a positive working atmosphere.

5.5 Innovation Needs

With the advancement in material technology, lots of innovations are happening in the design and other aspects of lighting. Thus, lighting should be Integrated with day lighting, should facilitate in communication Like Li-Fi, should absorb noise, should be able to use sun light directly like Light Pipe or Light Shelf etc.

6 DESIGN PARAMETERS OF OFFICE LIGHTING

The basic parameters for office lighting to be considered are “level of lighting on the working plane” and “human perception of brightness” which are correlated with illuminance (the incident light on any surface).

These together constitute “Visual Environment”. The other parameters include uniform brightness or lack of shadow/absence of darkness in between the illuminated surface, color rendering effect,

direction of light and glare minimization. These parameters influence visual comfort and performance.

However, besides the above, there are a few important factors which need to be considered for fulfilling the lighting requirements of the office spaces. Following are the lighting requirements:

6.1 Light Source

Light source is the prime factor in any office lighting design. Now LEDs are prominently used as light source in most of the interior as well as exterior spaces. LEDs are basically point sources in which the entire lighting is directed downwards. Hence, Glare minimization is essential which is achieved either through suitable covering for uniform diffusion of lighting without its absorption or through indirect lighting like ceiling reflected. This can also be achieved through deep down lighters.

These days, the majority of tasks are executed on computers due to the rising trend towards paperless and efficient office environments. It is therefore highly desirable that computer screens do not remain dark vis a vis background. Normally, computer screens are vertical. Adequate lighting on the vertical plane therefore needs to be considered for any office lighting design.

6.2 Basic Parameters

Lighting parameters are defined and quantified in the Lighting Standards published by Bureau of Indian Standards. Few important lighting terminologies are given here which are very frequently used in connection with office lighting:

6.2.1 *Luminous Flux* — It is the quantity of light emitted by a light source. It is dependent on the inherent quality of light source. Denoted by it is expressed in lumens (lm).

6.2.2 *Luminous Intensity* — It is the quantity of light radiated in a particular direction. This term is useful for lighting elements like reflectors. Denoted by I, it is expressed in candela (cd).

6.2.3 *Illuminance (E)* — It is the quantity of luminous flux falling on a certain surface. Its unit is lux which is lumens per sq. mtr of the surface area. Denoted by E and it is expressed in lux.

6.2.4 *Luminance (L)* — it is the basic lighting parameter perceived by the eye. It describes on the one hand a light source's impression of brightness, and on the other, a surface and therefore depends to a large extent on the degree of reflection (color and surface). Denoted by L and it is expressed in cd/m^2

6.3 Other Parameters

6.3.1 *Luminous Efficacy* — It is a measure of how well a light source produces visible light. It is the ratio of luminous flux to power, measured in lumens per watt in the International System of Units (SI). Normally, it is used in terms of system efficiency of lighting system.

6.3.2 *Glare* — Glare is difficulty of seeing in the presence of bright light such as direct or reflected sunlight or artificial light such as car headlamps at night. More specifically, it is a condition of vision in which there is discomfort or a reduction in the ability to see significant objects or both due to an unsuitable distribution or range of luminance or due to extreme contrasts in space and time. It is of two types, direct glare and reflected glare.

6.3.2.1 *Direct glare* — It is resulting from high luminance in the visual environment that is directly visible from a viewer's position.

6.3.2.2 *Reflected glare* — The variety of ill effects on visual efficiency and comfort produced by unwanted reflections in and around the task area. The effect of glare is loss of concentration, mistakes and fatigue

The remedy for direct glare is luminaires with limited luminance levels and blinds on windows. The remedy for reflected glare is matching luminaire to workstation (layout), indirect lighting and matt surfaces.

6.4 The UGR Method for Determination of the Glare

The standardized UGR method (Unified Glare Rating) is used to assess (psychological) glare. The UGR value is calculated with a formula which takes into account all of the luminaires in the system that contribute to the impression of glare. The UGR values for luminaires are determined using the table method pursuant to CIE 017.

6.5 Light Color

The light color is an important property of the light source. It describes the color appearance of the light. Color of the light also defines the basic atmosphere of the space as shown in Table 1.

Table 1 Color Appearance According to Color Temperature

(Clause 6.5*)*

Sl. No	Color	Color Temperature	Appearance	Association
(1)	(2)	(3)	(4)	(5)
i.	Warm white	up to 3300 K	Reddish	Warm neutral
ii.	White	3300K–5300 K	White	Neutral
iii.	Cool white	from 5300 K	Bluish	Cool

6.5.1 *Correlated Color Temperature (CCT) (K)* — The temperature of the planckian radiator whose perceived color most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions.

6.5.2 *Color Rendering* **—** Color rendering is the ability of a light source to reproduce surface colors as faithfully as possible compared to a reference light source. It is identified by the color rendering index (CRI). The best color rendering is $R_a = 100$.

Light sources are divided up into color rendering levels:

$R_a > 90$ very good color rendering

$R_a > 80$ good color rendering

Color rendering of less than 80 should not be selected at workplaces.

6.6 Illuminance Levels on Ceilings and Walls

If ceilings and walls are not lit up properly, an unpleasant room impression is created. Bright surfaces, however, pleasantly enhance the room climate. The minimum illuminance level prescribed are 30 lux or 50 lux* on ceilings and 50 lux or 75 lux* on walls.

7 HEALTHY INTEGRATIVE OFFICE LIGHTING

Over the years, office lighting has attained a new dimension. Humans are diurnal primates. Therefore, the focus is on achieving healthy office lighting. Healthy light is light provided by the sun most of the day, the color temperature of which is 6500 K. While designing human-centered integrative lighting for large open office spaces, the following factors are to be taken into consideration:

a) Circadian rhythm
b) Hormone production and suppression
c) Sleep Quality
d) Alertness
e) Mood

Over the last decade intensive research in Spectral Engineering has made available LED sources across the full range of CCT from 1800 K to 8000 K. These sources can now be selected and used in a wide variety of lighting applications

7.1 The Human Body Clock

Affected by melanopic vision. In this process, the natural blue light recedes when dusk sets in and thus offers warmer orange and reddish tones which helps the human body to produce more melatonin to maintain a proper sleep pattern. melanopic ratio (MR) is melanopic / photopic ratio. CCT for different LED sources can be tailored to produce a wide range of CCTs to support the desired MR ratio for multiple lighting applications. Holistic lighting design can thus be achieved

by correlating this with CIE coordinates. Table 2 shows the Standard LED CCT versus typical MR.

Table 2 Standard LED CCT Versus Typical MR

(Clause 7.1*)*

Sl. No	Standard LED CCT	Typical MR
(1)	(2)	(3)
i.	2700 K	0. 442
ii.	4000 K	0.668
iii.	6500 K	0.976

7.2 LED Lamps and LED Luminaires

Some important considerations for a smooth and efficient transition from conventional lighting to LED lighting are:

a) As a start replace all existing conventional fluorescent lighting in office spaces with T8 LED tubes.
b) Sensor based LED lighting for energy conserving measure.
c) Glare reduction by using micro prismatic diffusers which will also provide a uniform light distribution.
d) Trends in Luminaire design have remained more or less the same in order to ensure a smooth transition from FTL to linear LED fixtures, such as
    i. higher light output ratios;
    ii. use of prismatic rather than opal diffusers;
    iii. use of louvered design for low brightness;
    iv. batwing distribution for surface mounted luminaires; and
    v. trouser leg distribution for recessed mounting luminaires.

8 SPACE – BY – SPACE METHOD

8.1 Lighting Power Density (LPD)

Though lighting power density that is, the amount of power used by lighting per unit of building area, is an old concept it has now been established by international codes. The values established by the International Energy.

Conservation Code (IECC 2021) are based on the space-by-space method of calculation as shown in Table 3. It is to be noted that LPD is all power consumed by light fixtures, ballasts, controls, transformers, etc. – essentially, if the component or device is involved in lighting, it must be included in the calculation. This is the reason why LPD for conference room is higher than office despite light level being same. LPD for our country may differ from IECC codes, but for proper implementation of integrative lighting, LPDS must be worked out and incorporated in our national code.

Table 3 Space-by-Space Method of Calculation
(Clause 8.1*)*

Sl. No	Room Type	Light Level (Lux)	IECC 2021 Lpd (W/ Sq. Ft)
(1)	(2)	(3)	(4)
i.	Office (Open)	300 lux - 500 lux	0.61
ii.	Office-Private (Close)	300 lux - 500 lux	0.74
iii.	Conference Room	300 lux - 500 lux	0.97
iv.	Lobby	200 lux - 300 lux	0.84
v.	Locker Room (for Banks)	100 lux - 300 lux	0.52
vi.	Rest Room / Toilet	100 lux - 200 lux	0.63
vii.	Stairways	50 lux - 100 lux	0.49
viii.	Cafeteria	200 lux - 300 lux	0.40
ix.	Lounge (Break Room)	100 lux - 300 lux	0.59

8.2 Controls

The IECC code conceptually aims to minimize energy consumption by either of the following methods:

a) Automatic shut off
b) Light reduction
c) Daylight responsive controls

The following three inputs help in planning the controls:
a) Occupancy
b) A timed event
c) Ambient light level

Various manual controls for occupant convenience also help in additional energy savings with light, light reduction.

Continuous lighting is however required in security areas, interior exits, passageways, stairways, ramps

8.3 LLLC

It is defined by IECC 2021 as the lighting system comprising one or more luminaires with embedded lighting control logic, occupancy and ambient light sensors wireless networking capabilities and local override switching capability, wherever required.

Hence, incorporating lighting control functionality into the luminaires will ensure compliance to the energy code.

8.4 Special requirement for Open Plan Offices

Mandating occupant sensors in open plan offices 300 square feet (about the area of a parking space) and larger. This would ensure control of general lighting by sensors with control zones limited to 600 square feet (about twice the area of a parking space).

9 SELECTIONS OF LUMINAIRES

This is a very important task while designing lighting for any space. In earlier lighting sources, luminaires played a very significant role in lighting distribution and system efficacy, but with the introduction of LED, role of luminaires has been limited to glare minimization or providing different beam angles for different requirements. Hence in case of LED as a source of lighting, selection of luminaires is mostly dependent on specific usage and aesthetic requirements.

9.1 Design Dependent on Office Typology (Lighting Layouts)

The provision made for lighting will depend on the type of office, e.g., general office, executive office, drawing office, etc. and the subdivision of the floor space. Where the layout of partitioning is unknown or subject to alteration, provision should be made for a flexible installation that will allow luminaires to be placed in proper relation to any arrangement of partitioning. This flexibility may be achieved by either:

(a)providing fixed outlets on a modular system sufficient in number to ensure that luminaires can be located satisfactorily irrespective of how the interior is partitioned; or

(b)By using continuous lines of trunking or lighting track along which luminaires can be located as required.

The three main types of installation are as follows:

(a)Individual luminaires; ceiling mounted or suspended, supplied from fixed outlets or from continuous trunking or tracks;

(b)Recessed luminaires, usually modular, which may be inserted in the false ceiling; and

(c)Combination of localized lighting with (a) or (b) above. (Sometimes referred to as task lighting in conjunction with ambient lighting of a lower level).

Recessed modular luminaires do not provide any appreciable light on the ceiling and may be unsatisfactory in interiors having surfaces of low reflectance.

10 INTEGRATIONS WITH OTHER SERVICES

Wherever possible, the layout and operation of the lighting system should be designed in conjunction with other services. This involves dimensional coordination with the building module and positional coordination with the air input and exhausts terminals. The electrical power of the lamp and control gear contributes to the heat input of a building and allowance should be made for this in the design of the heating and cooling system.

10.1 With Air Conditioning

Air conditioning and lighting may be combined in such a way that the return air is exhausted through the luminaires. This is done primarily to:

a) reduce heat radiation from lamps and luminaires;
b) reduce temperature of the air surrounding the lamps thereby increasing their luminous flux and hence their efficacy; and
c) minimize openings in the ceiling to the extent the air exhaust can be affected through some luminaires.

The data (from luminaire manufacturers) concerning luminaires for use in an integrated system should provide information on the rate of heat removal, increase in luminous flux, air distribution and level of noise (due to exhaust air), apart from the usual lighting characteristics.

10.2 With Ventilation

Whenever any space like basement or kitchen or washrooms are lit, minimum lighting should be on if lighting controls using occupancy sensors are provided to avoid any untoward incidence to happen in these public places.

10.3 With Emergency Evacuation

Whenever any emergency arises when no normal power is available, in that event sufficient directional illumination must be made available for emergency evacuation. As such integration with fire alarm is required.

10.4 With Daylighting

Integration with daylighting is required to allow day lighting inside the confined spaces which are nearer to windows. This will help in allowing daylighting and in conservation of energy.

10.5 With Audio-Visual Equipment

This is required to provide automatic switching off general lighting whenever a presentation is going on. Since LED is a dimmable device, this can be easily achieved. This also effects energy conservation as well.

11 ENERGY EFFICIENCY/SUSTAINABILITY REQUIREMENTS

The ever-increasing cost of energy and resulting carbon emissions have necessitated the use of energy efficient lighting to be provided. In addition, lighting control measures, use of daylight by allowing maximum ingress of daylight, daylight integration with artificial lighting, better lighting design and layout, all together constitute an energy efficient lighting system.

11.1 Choice of Lighting System / Equipment

Choice Of The Light Source And Luminaire Is Based On Functional, Architectural And Energy Efficiency Requirements.

The advantages of LEDs like less power consuming, dimmability, availability in different colors etc. have given this light source the distinct edge and versatility over other light sources, such as T5 fluorescent lamp. However, it provides uniform light distribution with less energy consumption and can be an alternative solution in case LED tubes are not available.

11.2 Passive Daylight Harvesting System

11.2.1 *Sky Light* — A skylight is a light-transmitting structure that forms all or part of the roof space of a building for daylighting purposes. It has many advantages like adding natural light (and solar heating) to spaces, letting in fresh air and better ventilation, saving on energy costs (electric and heating) as illustrated in Fig. 1.

Fig. 1 Skylight Arrangements

11.2.2 *Light Pipe* — Light tubes are physical structures used for transmitting / distributing natural or artificial light for the purpose of illumination through successive internal reflections. It is an application of day lighting and are also called tubular day lighting devices, sun pipes, sun scopes, or daylight pipes as illustrated in Fig. 2.

Fig. 2 Light Pipe

9.2.3 *Light Shelf* — A day lighting system based on sun path geometry used to bounce the light off a ceiling, project it deeper into a space, distribute it from above, and diffuse it to produce a uniform light level below as illustrated in Fig. 3. In fact, it is a passive architectural device which reflects natural daylight into a building which is illustrated in Fig. 4.

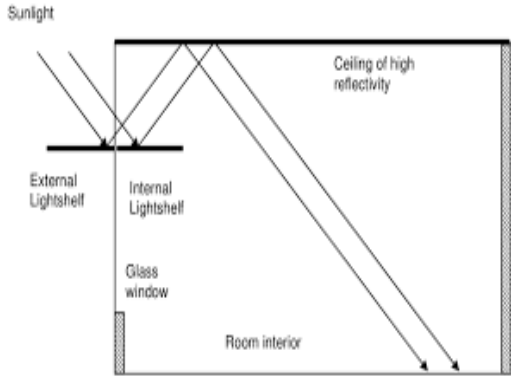

Fig. 3 Typical Use of Reflectors

Fig. 4 Day Light Integration in Architecture Design

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 3 Lighting for Educational Facilities

[First Revision of SP 72 (Part 5/Section 3)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49

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FOREWORD

Educational facilities refer to the infrastructure covering not only class-rooms and laboratories but also library, gymnasium, multipurpose hall, conference rooms, restrooms, cafeteria, circulation space etc. forming part of the institutional campus. Educational facilities may also include space for physical and sports education, center of fine arts, and media centers. Educational facilities are becoming increasingly specialized and complex with significantly varying requirements for a school level to the university level. Today, the traditional "classroom" facilitating the teacher-centric teaching-learning methodologies has been changed to a student centric classrooms with growth of computer-based instruction and video projection supported with latest ICT (Information and Communication Technology) connectivity.

The lighting system should provide optimal visual comfort for both students and instructors, with adequate levels of illumination that can be achieved through a combination of artificial and natural light, while also being mindful of energy efficiency. The lighting design should also take into account the impact on student attention and visual performance in the classroom.

1 SCOPE

This section outlines the principles and practices that govern the creation of a good visual environment in educational settings, encompassing nearly all aspects of interior lighting. It provides recommendations for the appropriate levels of illumination and quality that should be achieved through general lighting principles in educational facilities.

2 NORMATIVE REFERENCE

The following Indian Standards are necessary adjuncts to this Standard.

IS Number	*Title*
IS 6665: 1972	Code of practice for industrial lighting
IS 2672:1966	Code of practice for library lighting
IS 3646 revised part 3 1992	Code of practice illumination standard

The SLL lighting hand book - CIBS Publications

Licht publications - Good lighting for schools & educational establishments

3 TERMINOLOGY

The definitions of the terms used in this section are given in Part 1 of this code.

4 VISUAL TASK REQUIREMENTS

4.1 The primary activities for both students and instructors in educational settings involve reading and writing. These tasks can range from simple activities such as reading clear and bold printed matter, to more complex ones such as drawing, assembly work, and working with maps or graph sheets. At the university level, tasks may become even more complex, such as assembling smaller components or conducting complex lab experiments. These difficult tasks require higher levels of illumination to be performed effectively.

4.2 The age group for students may vary from 4-25 years whereas that for instructors in the range of 25 -60 years. This fact may demand the accommodation of the age factor to be accounted while considering the illuminance level.

4.3 The visual demands placed on school children tend to vary depending on the classroom environment. Students typically spend an average of seven to eight hours per day in school, for a duration of 10 to 12 years. Visual tasks in the classroom may involve sustained near work, such as viewing the chalkboard or listening to a lecture, or rapid changes in fixation, such as copying from the chalkboard or a material placed at a close distance. These visual tasks can place varying demands on a child's visual system.

4.4 In a classroom setting, students may need to look up at the board from a distance, while the teacher must have a clear view of the entire class while teaching. Distant viewing like this requires a good level of illumination, particularly as the illuminance requirement increases with age.

4.5 The required illuminance level is determined by the size of the object being viewed, the contrast, and the duration of the viewing. Typically, an illuminance level of 300 lux (horizontal) is considered adequate for teaching areas, while 100 lux is sufficient for corridors and 200 lux for gymnasiums. For more demanding visual tasks, additional localized lighting should be provided to achieve higher illuminance levels. When tasks with varying illumination requirements are to be performed in the same space, the illuminance level should be set to meet the requirements of the most demanding task. If this results in excessive levels, lower levels can be used, with supplementary localized lighting provided for specific tasks that require higher levels, such as drafting tables and chalkboards.

4.6 Illumination in the vertical plane is necessary for optimal viewing conditions, particularly for chalkboards, display charts, and similar materials. In many cases, this requirement is automatically met by the lighting sources used for general (horizontal plane) illumination. However, supplementary local lighting may be required in certain instances. For example, corridors not only serve as passageways, but may also be used to display bulletins, charts, posters, and notices, necessitating additional localized lighting to supplement the general corridor lighting.

4.7 In areas where colour rendition is an important parameter (as example art rooms, chemistry laboratory) the source should be selected for a high CRI (above 75). Efficient light sources with good CRI and luminaires should be carefully selected to work in combination with daylight, in order to provide the proper quantity of high-quality, comfortable lighting.

5 VISUAL ENVIRONMENTAL REQUIREMENTS

5.1 Students often have to engage in prolonged periods of close attention, requiring them to alternate between nearby and far-off viewing. This can cause discomfort and fatigue, particularly when the eyes are forced to adjust quickly and frequently to vastly different luminance. To avoid such discomfort, it is essential to create a good visual environment. Several factors contribute to this, including:

a) *Proper illumination* — Adequate levels of illumination should be provided to ensure that visual tasks can be performed with ease and without straining the eyes.

b) *Contrast* — The contrast between the task and its background should be optimized to minimize eye strain and improve visual performance.
c) *Glare control* — Proper control of direct and reflected glare is crucial to maintain visual comfort and prevent eye fatigue.
d) *Color rendering* — Good color rendering can help to enhance the clarity and legibility of printed or displayed materials.
e) *Lighting uniformity* — Uniformity of illumination across the visual field is important to minimize visual adaptation and provide a comfortable visual environment.

By taking these factors into account, educational institutions can create a visual environment that supports students' learning and promotes visual comfort.

5.2 To create a comfortable and efficient visual environment, it is recommended that the surfaces within the space have appropriate levels of reflectance. Specifically, walls should have a reflectance of 40 to 60 percent, ceilings should have a reflectance of 70 to 90 percent, and flooring should have a reflectance of over 25 percent.

These levels of reflectance help to create a comfortable and uniform luminance pattern throughout the space, reducing the potential for glare or other visual discomfort. Additionally, these reflectance levels can contribute to improved energy efficiency by maximizing the use of natural and artificial lighting within the space.

5.3 To ensure good visual adaptation and comfort for students, the lighting system and environment should be coordinated to achieve the following results:

i) The luminance of the desktop or work surface should not exceed the luminance of the task being performed, nor should it be less than one third of the task luminance.

ii) No surface within the student's field of view should have a luminance lower than one third of the task luminance.

iii) The luminance of any surface within the student's field of view should not exceed 5 times the luminance of the task being performed.

These guidelines help to ensure that the lighting and visual environment are appropriate for the task at hand, reducing the potential for visual discomfort or fatigue.

5.4 To avoid direct glare from lighting, it is important to ensure that luminaires are not too bright from normal viewing angles. This is especially important in classrooms where students frequently shift their gaze from their desks to other areas of the room. In addition, the ceiling should be bright enough to provide a comfortable background for the luminaires, with at least 10% of the light directed towards the ceiling. By following these principles, direct glare can be minimized and a comfortable visual environment can be achieved for both students and instructors.

5.5 Additionally, the lighting on the board should be uniform and free of shadows, as shadows can reduce the legibility of the writing. The board should also be positioned in a location where there is minimal glare from windows or other light sources. Similarly, the lighting on the student's desks should also be uniform, without any glare or shadows, to avoid eye strain and discomfort.

5.6 The majority of classrooms are equipped with windows that allow for a significant amount of natural light. However, it is important to avoid direct sunlight and glare inside the classrooms while still benefiting from daylighting. This can be achieved through the use of exterior architectural features such as shades, blinds, louvres/baffles, and roof overhangs, as well as proper building orientation. Since daylight is a variable source, it may be necessary to supplement it with an electric lighting system that includes appropriate switching arrangements.

5.7 In lecture theatres in colleges, (where the room sizes are larger compared to schools) attention should be given for unobstructed sight lines and dimming of lights for the use of various visual aids. Dimming facility may be needed in large halls where visual aids are likely to be used, and also where practical experiments in the subject of lighting will be conducted.

5.8 The lighting arrangements for audio-visual systems should be tailored to suit the presentation media and its intended use. Display systems typically have luminances and resolutions that allow for clear visibility in various classroom lighting conditions. However, if the pedagogy involves exclusive viewing of electronic displays, appropriate measures should be taken to meet the required level of brightness.

5.9 Daylighting should be utilized wherever possible, and the operation of electric and daylighting mechanisms should be user-friendly for instructors. The functionality of the room, including the ability to darken it for audio-visual presentations, should be easily accessible. In classrooms, special attention should be paid to the following aspects:

a) The availability of automated or stepped dimming functionality, which should be free of glare.
b) Daylight apertures should be introduced on orientations other than the primary or secondary instruction or presentation positions, while maintaining some degree of exterior view for the classroom.

5.10 Improving the visibility of chalkboards can be achieved by proper lighting, which also helps maintain the attention of the audience. Grazing light produces a high level of luminance near the light source, which can be offset by positioning the room lighting to brighten the bottom portion

of the board. This will create a balanced effect and ensure better visibility of the content on the board.

5.11 To achieve appropriate horizontal and vertical illuminances on tables and faces, a combination of ambient and task lighting systems is used. For lab work, lensed task lighting is incorporated into overhead lab utility carriers, and tables are positioned directly below these carriers. Ambient lighting is provided by lensed 1x4 luminaires, with the outside row strategically placed to illuminate glass-front storage cabinets. Ceiling-recessed rectilinear wallwashers, using long compact fluorescent lamps or linear lamps, can be used to accentuate whiteboards. Each lighting system can be controlled separately to accommodate different teaching situations. The indirect lighting component reflects diffuse light from the ceiling, which provides vertical illuminance and aids in facial recognition in rooms with VDT screens.

5.12 Stairs that are frequently used by many students during class changes require higher illuminance than stairs that are used in normal situations. Control systems play a crucial role in providing functional variation, daylight integration, and user-friendly operation for all classroom applications.

5.13 For interior production and work-oriented spaces, a baseline of 90-60-20 for percentage light reflectance values (LRVs) of ceilings, walls, and floors respectively is recommended. This should be achieved by utilizing daylighting that meets the necessary luminance and illuminance criteria, and using the highest-efficacy lamps that meet color, optical, and electrical control, and output criteria. Additionally, highest-efficiency luminaires should be used to meet aesthetic and luminance criteria, with accenting employed to provide luminance balancing or improve brightness perceptions where necessary.

6 CLASS ROOMS/ LECTURE HALLS

6.1 General

The evolution of classrooms from traditional setups, which featured blackboards and paper-based tasks, to modern classrooms, which feature whiteboards, computers, and video projectors, poses certain challenges for lighting systems. While these new technologies provide teachers with increased flexibility and enable the use of multimedia resources such as PowerPoint presentations, the internet, and videos, they also require appropriate lighting to optimize visibility and enhance visual comfort. Lighting systems must be designed to minimize glare and provide appropriate contrast for optimal viewing of digital displays, while also ensuring that traditional writing surfaces remain visible and legible. Additionally, lighting levels must be adjustable to accommodate various types of multimedia presentations, and consideration should be given to the impact of lighting on the overall learning environment, including the mood and productivity of students and teachers.

6.2 To ensure optimal viewing of the whiteboard while minimizing energy consumption, it's important to provide adequate vertical illumination for contrast without over-lighting the entire classroom. However, excessive vertical illuminance can negatively affect the image of video projectors, limiting their effectiveness. To address this, a dedicated luminaire can be used to illuminate the whiteboard on the main teaching wall, while indirect/direct luminaires with suitable control can be used to provide quality, glare-free illumination for the rest of the classroom. This can help to evenly illuminate ceilings and walls.

6.3 In modern classroom may require multipurpose lighting to accommodate a numerous of educational activities, such as direct instruction; group work; individualized instruction, including computer work; and audiovisual (AV) presentations. To complement such activities throughout the long studying hours, with needed focus and energy from students, the 100% dimmable Tunable White Lighting (TWL) with the range of CCT from 2700 K to 6500 K while maintaining a good CRI can be provided in the classroom.

6.4 In classrooms, it is essential to control the veiling reflections on video monitors, tablets, and computer screens. While producing vertical illumination on whiteboard and smart board surfaces, lighting arrangement should maintain the desired contrast for aiding the visibility from anywhere in the classroom. It should also facilitate the viewing and note-taking during audiovisual (AV) presentations.

6.5 In educational facilities, use of the classrooms by students and staff contributes to almost 50% of the net time spent. So adoption of the energy savings techniques are very much essential. Incorporating daylight and occupancy sensing to provide automatic control of lighting zones to further reduce energy consumption.

6.6 Classrooms may need to incorporate the adjustable lighting to assist vision-impaired students. In general lighting system should provide better color rendering and improve visual comfort. Classroom lighting arrangement can be mode based viz. 'Normal' mode for regular classroom activities; 'Energy' mode to revitalize when children need to be more active; 'Focus' mode to aid concentration during challenging tasks and 'Calm' mode to relax during individual work or quiet time.

6.7 In order to achieve a visual comfort in the classroom, the recommended maximum luminance variation between areas of appreciable size from normal view points should be as follows:

a) 1 to 1/3 between task and adjacent surroundings (such as between a book and the desk top).

b) 1 to 1/3 between task and more remote darker surfaces (such as between a book and the floor), and

c) 1 to 5 between task and more remote lighter surfaces (such as between a book and a window).

6.8 Corridors in educational institutions not only serve as mere passage/transition areas, but also are used to put up displays, bulletin boards, wall magazines, posters, notices, etc. Special lighting should, therefore, be provided in addition to a good general lighting to enhance the visual vitality of such corridors.

7 **LIBRARY AND READING ROOM**

7.1 General

Library is an critical area in an educational complex, involving significant variety of visual task including reading, both casual and sustained, examination of drawings and maps, writing, use of computers desktops for e-book/ e-journal reference etc, In addition, the lighting system in libraries and language labs should provide proper vertical illumination for reading and viewing of screens and displays, while minimizing glare and reflections. Task lighting should be provided at individual workstations and study areas, with the option for individual control. The use of daylighting should also be considered, with proper shading and glare control measures in place to ensure optimal visual comfort. A combination of ambient and task lighting, with the option for dimming and control, can provide flexibility and energy efficiency.

Vertical lighting level is an important aspect to consider when designing lighting for libraries. By providing adequate vertical illuminance, the contrast and legibility of printed materials can be improved, while minimizing the concentration of light directly downward can help reduce the veiling reflections that can reduce contrast. Additionally, avoiding direct and indirect glare can help reduce visual discomfort and improve reading comfort. The use of non-glossy finishes on decorations and furnishings can also help reduce reflections and glare in the space. Overall, high-quality lighting design can help create a comfortable and productive environment for library users.

Overall, the goal of library lighting design should be to create a welcoming and functional space that encourages people to use the library and its resources to their fullest potential.

In addition to the general lighting requirements, special lighting considerations are required for library exhibits and displays. Lighting levels should be carefully controlled to avoid damage to sensitive materials such as rare books, manuscripts, and artwork. Specialized lighting equipment should be used, such as low UV and IR emitting lamps or filters, to reduce the risk of fading or discoloration. Light levels and color temperature should also be tailored to the specific requirements of the materials being displayed, and lighting should be arranged to minimize glare and unwanted reflections.

7.2 Installation

7.2.1 Indeed, the open plan library design is often preferred for its flexibility and adaptability. However, it may not always be possible to avoid the need for local lighting of tables and desks, especially if the positioning of the luminaires is limited by the building's form or predetermined arrangements. In such cases, a compromise may be necessary to ensure that both the general lighting and the task lighting needs are met.

It is important to ensure that the general lighting system provides even illumination throughout the library while avoiding direct and indirect glare. The use of indirect/direct luminaires with suitable control can provide quality glare-free illumination and yield evenly illuminated ceilings and walls. Additionally, a dedicated luminaire can be used to illuminate the whiteboard on the main teaching wall and for other task areas where appropriate.

Overall, the lighting design of a library should consider the various activities and tasks that take place within the space, including reading, studying, research, and presentations. Proper illumination levels, color rendering, and uniformity should be achieved while also taking into account energy efficiency and the preservation of the library's collections.

7.2.2 In reference rooms and reading rooms, local lighting combined with general lighting giving a lower illuminance may be an economic solution. Also lighting control with auto-dimming facility with occupancy sensor can result in energy savings.

7.2.3 Indirect lighting by means of concealed lamps, placed on the tops of symmetrically arranged book stacks, is sometimes adopted, as it avoids the presence of visible luminaires. Unless augmented with local lighting, however, running costs (energy and maintenance) will be relatively high and the ceiling may become a source of discomfort glare or distraction.

7.3 Book Stacks

7.3.1 Identifying books on book spines can be challenging due to the need to refer to their numbers and authors. Book stacks located around the perimeter of reading rooms are typically lit by the room's general lighting system, while those along the center of the aisles are illuminated by fluorescent luminaires with customized distributions in continuous rows.

7.3.2 Although identifying books in book stack areas may seem straightforward, factors such as labeling, lettering, and book positioning can impact ease of visibility. The narrow width of the aisle between the stacks makes it impractical to achieve consistent lighting from top to bottom of the shelving. To enhance visibility, the material or finish of the shelving and floor covering should be of a light color to facilitate inter-reflection of light at the bottom of the stack. If a minimum illuminance of about 50 lux is maintained on the vertical plane and there is good luminance contrast between the book titles and their background, visual performance will meet an acceptable standard.

7.4 E-Book Reference Section and Language Lab

Due to the presence of desktop and visual aids like video projector in this section, the lighting should be designed carefully to avoid the glare and should have dimming facility.

7.5 Above gives the general guidelines to be followed in designing the lighting for libraries. For further details regarding principles and practices governing good lighting reference should be made to IS 2672:1966.

8 LABORATORIES

8.1 These tables or benches are used for carrying out highly detailed work such as dissection, inspection of reactions, instrumentation experimentation, and measurement in laboratories. Effective diffusion with a directional component and suitable color quality is necessary. If the building design, such as window sizes and orientation, requires it, localized lighting may be necessary and should be coordinated with users.

8.2 For laboratories where chemical analysis is performed or where corrosive fumes and vapors are present, it is advisable to use luminaires that can withstand the harmful effects of the chemical fumes in the atmosphere. Alternatively, the body and supports of the luminaires can be painted with anticorrosive paint.

8.3 At university level facilities, the laboratories may include the complex assemblies of components and machining work. In such laboratories, general lighting of 300-500 lux level should be provided with supplementary localized lighting.

8.4 Laboratories and electronics test labs or workshops may have specific lighting requirements for processes, viewing, and hazards present in the environment. If fume hoods or paint/finishing booth packages do not include integrated lighting, it is necessary to design lighting for hazardous locations. Similar lighting systems are also necessary for motor and vehicle servicing, prototyping, and experimentation in SimiMotor environments.

8.5 In lab experiment stations and observation booths, it is important to establish lighting needs if equipment or booth vendors do not provide integrated lighting. If the processes involve hazardous chemicals, lighting must be designed for hazardous locations. For spectrally sensitive processes, such as some curing procedures, appropriate lamps should be selected. Similarly, for processes that are both spectrally and intensity sensitive, such as plant growth, appropriate lamps should be selected. In situations where luminaires need to accommodate directed water spray or wash-down procedures, wet-rated luminaires with IP ratings specific to the situation are necessary.

8.6 In situations where color discrimination is critical to the task process, such as assessing chemical reactions in experiments or matching paint color and finish quality in shops, a Color Rendering Index (CRI) of at least 90 and Correlated Color Temperature (CCT) of 5000 K or 6500 K may be necessary. For more information, please refer Part 2/Sec 3 of this code.

8.7 Provision in form of convenient outlets should be kept for portable lighting equipment required for microscope work and in reading precision instrument and meters.

8.8 In an Electronics Laboratory, it is important to provide suitable filter circuits in fluorescent lamp luminaries to suppress radio frequency interference. Clean type luminaires that are free of UV radiation should be used, and a minimum of IP54 luminaires should be used to ensure protection from dust and other particulates.

9 AUDITORIUM

9.1 General

An auditorium serves many purposes such as an assembly and lecture hall, study room, theatre, concert hall, and more. As a result, it is essential to plan and equip the auditorium properly to meet the needs of all these functions. From general lighting to supplementary illumination, it is important to provide good lighting that blends well with the architecture and avoids veiling reflections. Careful consideration should be given to the lighting design to ensure that it enhances the overall experience for all activities in the auditorium. In particular due consideration should be as given in 8.2 and 8.3.

9.2 Specific Areas in an Auditorium

9.2.1 *Foyer*

In the foyer of an auditorium, a restful and subdued atmosphere is usually desirable. One effective method is to use illumination from large, low luminance elements such as coves. Wall lighting and accents on paintings, posters, and plants are also important for creating the desired atmosphere. It is important to take care that the light does not spill into the auditorium and disturb the experience of the audience. Properly designed and directed lighting can contribute to the overall ambiance of the foyer without impacting the main event in the auditorium.

9.2.2 *Seating Area*

To ensure comfort and visibility for the audience, the seating areas in the auditorium should be well-lit with well-diffused illumination. Suitable luminaires for basic illumination may include general downlights, coves, curtain and mural lights, among others. In addition to basic illumination, a supplementary downlighting system should be provided evenly over the seats to ensure proper visibility for any visual tasks. It is important to control all these lights separately and have them under dimmer control to allow for adjustments in illumination levels as needed during the event. Proper lighting design can help ensure that audience members are able to see and enjoy the event without experiencing visual fatigue or discomfort.

9.2.3 *Stage Area*

The appropriate use of lighting in a dramatic performance goes beyond simply ensuring visibility, as it also serves to enhance the artistic composition, create mood effects, and reveal three-dimensional forms. These effects are achieved through the careful manipulation of qualities such as quantity, color, and direction of light, which may vary from one performance to another and even within a single performance. The layout of the lighting is influenced by the planned use and purpose of the theatre.

9.3 Control System

It is recommended to provide dimming capabilities for an auditorium, regardless of the size of its stage. When dimming is necessary, it is preferable to use GLS light sources in the lighting design. The selection of dimmers should be based on budget and ease-of-use requirements. Various types

of dimmers are available, including auto-transformer (manual and motor-driven), thyratrons, saturable reactors, magnetic amplifiers, and thyristors (SCRs), among others.
When designing the lighting arrangement, care should be taken to enable specific groups of lights to be controlled in specific areas when needed.

9.4 Regardless of its size, an auditorium should have emergency lighting installed. It is important to ensure that all aisle lights, lights for steps, and lights at the rear of the seating area are connected to the emergency circuit. Additionally, exit lights should be provided at every access point to guide the audience towards the exits in the event of a power failure.

9.5 In small institutions, it is common to use the multipurpose hall as a gymnasium. While a high general lighting level may not be necessary for this application, it is important to avoid glare from the light source. When the hall is used for indoor games, lighting should be provided in accordance with the recommendations for the specific type of sports activity. For further details on sports lighting, please refer to Part 6, Section 5 of this code.

10 STAFF ROOMS

The staff room is a place where teachers gather for discussions, studying, and resting during recess periods. These rooms should have general illumination for performing visual tasks such as reading and writing, including correcting papers and notebooks. The switching arrangement should allow for a group of lights to be turned off to achieve a subdued level of around 200 lux when the occupants wish to relax.
In addition, supplementary local lighting should be provided in the form of table lamps or wall lamps positioned to the side of the user. This enables an individual to continue with their work without disturbing others who may be relaxing at the same time.

11 CORRIDORS AND CIRCULATION AREA

In educational institutions, corridors and circulation areas are not only used as passage/transition areas but are also utilized for displaying items such as bulletin boards, wall magazines, posters, notices, and other materials. Therefore, it is important to provide special lighting in addition to good general lighting to enhance the visual impact of these corridors and circulation areas.

12 SPECIFIC AREAS

12.1 Art Rooms

Since color is crucial in these areas, it is recommended to use light sources with high color rendering capability to bring out a more natural appearance of colors across a wide range. In addition, supplementary lighting from directional concentrating sources should be used on displays and models for improved visibility and modeling purposes.

For further details, refer Part 5/ Sec 7 of this code.

12.2 Workshops

When it comes to lighting in workshops, it is important to provide sufficient quantity and quality of illumination required for optimal performance of a given task. Additionally, lighting should also aid in the safety of personnel working in the workshop.

For guidance regarding general features and factors that influence good lighting practices for workshops, reference should be made to IS 6665. This document provides detailed information on how to achieve effective lighting in workshops while considering factors such as task requirements, glare control, and color rendering.

12.3 Gymnasiums

A gymnasium is a multi-purpose area that serves a variety of needs for students and the community, including assemblies, concerts, dances, and various sports activities. In addition to providing good general illumination, portable temporary auxiliary equipment should be used wherever creating a specific mood or atmosphere is desired.

To protect the luminaires in a gymnasium from flying balls, shuttles, and other hazards, wire guards or other means of protection should be provided. It is also important to properly locate and shield the luminaires and fenestration to prevent hazardous conditions.

Glare control and flicker should also be given priority in gymnasium lighting design. For further guidance on these criteria, please refer to the chapter on adverse effects of lighting.

12.4 Cafeterias and Kitchens

In eating areas, the lighting should not only create a cheerful and comfortable ambiance but also provide adequate illumination for various activities. For instance, if the dining area is used for other tasks like reading or working on laptops, the lighting levels should be suitable for such tasks. When it comes to food service areas like cafeterias, the lighting should enhance the appearance of food through the use of pleasant colors and appropriate light sources. Additional incandescent lighting may be used over the serving counter to make the food visually appealing, provide warmth, and aid in the quick selection of food.

In the kitchen, good general lighting is crucial, particularly in areas such as ranges, work tables, and sinks to ensure cleanliness, safety, and good housekeeping practices.

13 LIGHTING CRITERIA FOR VISUAL PERFORMANCE AND COMFORT IN EDUCATIONAL INSTITUTIONS

13.1 General

In addition to general illumination, adequate local lighting is essential for such tasks as projection, reading from notes, operating audiovisual equipment, etc. Control of lighting levels, and the ability to adjust and dim the lighting is necessary in order to achieve satisfactory contrast conditions for the use of various visual aids.

In laboratories, task lighting will generally be needed over workbenches, fume hoods, microscopes, and other specialised equipment. It is also important to avoid shadows and glare on working surfaces, and to ensure that the lighting is uniform and of adequate intensity.

In addition to the above, consideration should also be given to the type of light sources to be used, their colour rendering properties, and the need for energy efficiency. Proper maintenance of the lighting system is also important to ensure that it remains effective over time.

13.2 Illumination (Quantity)

An illuminance of 300 lux is recommended for teaching areas. Both horizontal & vertical lighting is important for students to concentrate long hours spent in the educational institute. Higher luminance should be provided for more exacting visual tasks, for example, 500 lux for laboratories.

13.3 Quality of Lighting

13.3.1 In addition to the above, consideration should also be given to the energy efficiency of the lighting system. The use of energy-saving lamps, such as LED lamps, should be considered wherever possible. Control systems, such as occupancy sensors and daylight sensors, can also be used to reduce energy consumption by automatically turning off or dimming the lights when the space is not in use or when sufficient natural light is available.

It is also important to consider the maintenance of the lighting system, particularly in areas with high ceilings where access can be difficult. The use of long-lasting lamps and luminaires with easy maintenance access can reduce maintenance costs and inconvenience.

Finally, it is important to comply with local regulations and standards for lighting design and installation to ensure safety and compliance with local codes.

Color properties like color temperature and color rendition as well special distribution of lighting are most important factor to consider while doing the lighting plan. Light direction & modelling also important factor based on area of the institute.

Light color based on requirement and chose which can 3000 K to 6500 K. In general, 400 K is optimum recommended light color for topical country like India. However, choice is wide open depending on user. Color rendition recommended more than 75. Preferred Ra should be 80 to 85.

14 DAYLIGHT CONSIDERATIONS

14.1 Taking advantage of natural daylight is not only energy efficient but also provides a more pleasant and comfortable environment for students and faculty. Therefore, the design of the lighting system should take into account the availability of daylight and provide appropriate switching arrangements to ensure that the lighting system is used efficiently. This can help reduce energy consumption and operating costs while providing a well-lit environment for learning and other activities.

15 RECOMMENDED ILLUMINATION LEVELS, average lighting level AND GLARE INDEX

The horizontal/vertical illuminance levels, uniformity and glare index recommended for the different areas in educational facilities are given below as a guide line:

Sl. No	**Areas**	**Horizontal Target Illuminance (lux)**	**Vertical Target Illuminance (lux)**	**Uniformity Avg : Min**	**Glare Index**
(1)	(2)	(3)	(4)	(5)	(6)
i)	Computer labs	150-300	75-150	2:1	
ii)	Staff room	150-300	100-200	2:1	16
iii)	Laboratory	250-500	150-300	2:1	16
iv)	Drawing Halls	250-500	50-100	2:1	16
v)	White board	-	150-300	3:1	
vi)	Gymnasium	250-500	100-200	3:1	
vii)	Sports centers	250-500	100-200	3:1	
viii)	Cafeteria	50-100	30-50	3:1	

ix)	Corridors / Circulation Spaces	50-200	30-75	2:1	
x)	Reading room	150 to 300	--	3:1	19
xi)	Auditorium -Stage	50-1000	25-500	3:1	16
	Auditorium -Hall & Foyer	100	30-40		
xii)	Reception	400	150	3:1	
xiii)	Waiting Area	200	100	3:1	
xiv)	Stairs	100	50	2:1	
	Library				
xv)	Book Stacks	200	100	0.5	16
xvi)	Book Drop	150	50	0.5	
xvii)	Reading Area	500	100	0.5	
xviii)	Rare Books/Archival Storage	300	100	0.5	
xix)	Digital display	150	50	0.5	
xx)	Hand written Work	400	75		
xxi)	Print Media	300	50		
xxii)	Book sorting Room	300	100	0.33	
xxiii)	Copy/Print Rooms	300	100	0.33	
xxiv)	Stairs	100	50	0.5	
	Classrooms				
xxv)	Art Studio	500	300	0.33	
xxvi)	VDT Screens	150	50	0.5	
xxvii)	Chalkboard		400	0.33	

xxviii)	Whiteboard		300	0.33
xxix)	Lecture Hall	100	40	0.33
xxx)	AV & Notes	50	15	0.5
xxxi)	Projection Screen		10	0.5
xxxii)	Science Lab Bench	500	300	0.5
xxxiii)	Science Lab Demo area	1000	500	0.33
xxxiv)	Study Hall	300	200	0.5
	Conference			
xxxv)	Presentation Surfaces		100	0.33
xxxvi)	AV	30	30	
xxxvii)	Video Conference display		200	0.5
xxxvii)	Video Conference Faces	300	400	0.66
xxxviii)	Video Conference Table	300		0.66
xxxix			300	0.66

Illuminance level may be kept half of the mentioned values for average age (visual) less than 25 years, Unified Glare Index Ratio is recommended to be within 20.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 4 Hospital Lighting

[First Revision of SP 72 (Part 5/Section 4)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49

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FORWARD

Light is crucial for human functioning as it enables us to see and engage in activities. Moreover, light plays a significant role in affecting human psychology and physiology. Several studies have documented the importance of light in reducing depression, decreasing fatigue, improving alertness, modulating circadian rhythms, and treating conditions such as hyperbilirubinemia among infants.

This chapter considers the mechanisms by which light impacts human health and performance and reviews linking light (daylight and artificial light) with health outcomes in health-care settings.

Most healthcare settings, along with other buildings, are lit by a combination of daylight entering through windows and skylights, as well as electric-light sources. It is important to understand how these two types of light sources differ to understand their relative impacts on human health and performance. Sunlight is electromagnetic radiation in the wavelength range that can be absorbed by the photoreceptors of the eye. Sunlight provides a balanced spectrum of colors with elements

in all parts of the visible wavelength range. The actual wavelengths present in daylight vary over the day with latitude, meteorological conditions, and seasons.

In contrast, light from most artificial electric-light sources compose of wavelengths of lights that are concentrated in limited areas of the visible light spectrum, such as yellow to red end or orange to red end of the spectrum. Full-spectrum electric-light sources that have a spectral content similar to daylight, though their spectral content does not vary over time, are now available. Natural light has benefits over electric-spectrum in maintaining overall health.

Lighting place a significant role in achieving basic social safety and environmental objectives. The intent of this chapter is to encourage good lighting practices and systems which would minimize light pollution, glare, light trespass and conserve energy while maintaining safety, security, utility and productivity. The lighting industry is highly fragmented and has relatively low technical barriers to entry.

Provision of a good lighting system calls for coordination from the initial stages among the various parties concerned, namely, the architect, the medical consultant and the illumination engineer. Therefore, it is essential that information regarding lighting should be exchanged between the parties from the stage of planning to installation.

This revision has been undertaken to update the current reference for healthcare lighting design and to align the standard with the latest developments that have occurred in the lighting space.

1 SCOPE

This chapter covers the followings:

a) guidance on illuminating engineering practices to be followed by various types of occupancies.
b) guidance on good engineering practices to be followed for designing, selecting, installing and maintaining of lighting system for indoor and outdoor areas
c) matters related to the science of illumination such as physics of life, electric light sources, luminaires and photometry.
d) coordination aspects to be considered while designing the lighting system.
e) all aspects relating to energy management and energy conservation in lighting installation including guidelines for design and good practices to be adopted for effective and efficient use of light sources.

2 REFERENCES

IES RP-29-16 Lighting for Hospitals and Healthcare Facilities

3 DESIGN CRITERIA

3.1 Observer Visual Age Consideration

The Illuminance recommendation identifies different illuminance targets based on age.

There are three age categories: younger than 25, between 25 and 65, and older than 65.

The document represents a patient-focused approach to illumination, based on an incredible amount of recent research. The outcome of this research is a set of recommendations that encompass the comfort, functionality, safety, health and wellness, and sustainability aspects of a project.

This chapter recommends two lighting levels for the entrance of a general lobby. It recommends one light level for daytime and one for nighttime.

3.2 Types of Facilities

The healthcare facilities are categorized as acute care, ambulatory care, or long- term care.

While the needs of the facility often vary by category, seven consistent themes that are desired in the healthcare environment are as follows and the facility must:

a) bolster connections to staff and caregivers;
b) fosters a sense of well-being;
c) be convenient and accessible;
d) supports confidentiality and privacy;
e) facilitate personnel care for family needs;
f) must be designed and considerate of physical impairments;
g) have a connection to nature and the outside world.

4 GENERAL DESIGN REQUIREMENTS

4.1 Daylighting

Light impacts human health and performance by enabling performance of visual tasks, controlling the body's circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body. By controlling the body's circadian system, light impacts outcomes in healthcare settings by reducing depression among patients, decreasing length of stay in hospitals, improving sleep and circadian rhythm, lessening agitation among dementia patients, easing pain, and improving adjustment to night-shift work among staff. The presence of windows in the workplace and access to daylight have been linked with increased satisfaction with the work environment. Further, exposure to light is critical for vitamin D metabolism in the human body. Adequate and appropriate exposure to light is critical for health and well-being of patients as well as staff in healthcare settings.

A combination of daylight and electric light can meet these needs as shown in Fig. 1. Natural light should be incorporated into lighting design in healthcare settings, not only because it is beneficial to patients and staff, but also because it is light delivered at no cost and in a form that most people prefer.

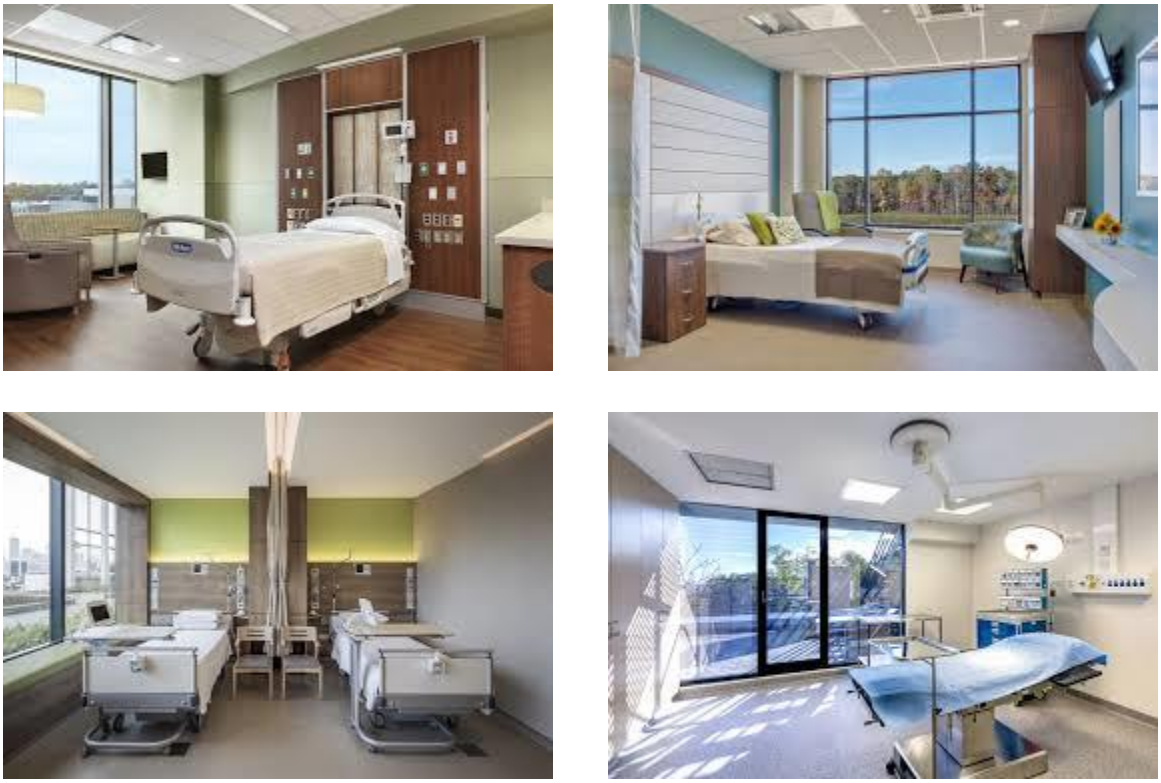

Fig. 1 Synergy of Daylight and Electric Light in Healthcare Environment

The following guidelines are crucial for effective daylight integration in hospitals:

a) Lighting design shall strive to employ daylighting practice in the design of the facility.
b) When appropriate, lighting control strategies should integrate daylighting and electric lighting to achieve sufficient high-quality illumination.
c) Location of windows and skylights in a building must be designed to avoid the admittance of direct sun on task surfaces or occupants.
d) Suitable glare control devices such as blinds or shades should be provided.
e) Daylight harvesting controls must be commissioned. The system must have the lighting set points properly configured if the system is to properly respond to available daylight.

4.2 Energy Conservation

The lighting design should take care of the energy conservation with respect to every aspect of the lighting system and also ensure integration of daylight and the selection of the right luminaires that meets the requirements of energy savings and hence sustainability.

The following strategies should be used to ensure that the lighting design shall:

a) include task lighting that allows occupant to achieve task-focused illumination.
b) include daylight harvesting where practical.

c) use vacancy sensor instead of occupancy sensor where practical.
d) use occupancy sensors in public rest rooms and large multi-occupant spaces.
e) select luminaires with maximum efficiency.
f) avoid lighting above or in front of illuminated vending machines.
g) limit facade lighting to public entrances.
h) include automatic lighting control system in conjunction with bypass switches for lighting circuits in non-patient care areas and where practical.

4.3 Lighting Design Strategies

In order to achieve design objectives as stated in this chapter, design strategies should be employed with a focus on the function/use of the space/room and the occupants/end-users.

4.4 Lighting Design Objectives

Lighting design shall meet the following primary objectives:

4.4.1 *Interior*

a) Design for safety and security — Lighting systems shall effectively support patient care and safety, life/fire safety and security for patients, staff, and visitors.

b) Design for function — Lighting systems shall provide sufficient level of lighting for occupants to effectively perform designated tasks and functions.

c) Design for visual comfort — Lighting systems shall contribute to the visual comfort for patients, staff, and visitors. Glare should be mitigated using practical design methods and correct specification of luminaires.

d) Design for maintenance and operation — Lighting systems shall be easily maintained and operated. Similar components of luminaires from different manufacturers should be compatible and interchangeable.

5 PATIENT AREAS - LIGHTING GUIDELINES

Fig. 2 Illumination in Patient Areas

5.1 Specialty, Diagnostic, and Treatment Areas

5.1.1 *Examination and Treatment Room Design Parameters*

The illuminance in the surgical field is determined by the type of surgical procedure, the depth of the body cavity to be illuminated, and the angle of illumination. Consequently, different surgical procedures will require operating luminaires of varying luminous intensities and illuminated field sizes as shown in Fig. 2. In a large operating theatre suite each theatre may be equipped with an operating luminaire specifically suited to the type of surgery to be undertaken in each theatre. In smaller suites where various types of surgical procedures will be undertaken in the same theatre, it will be necessary to select an operating luminaire that will provide the best all-round solution.

a) Average Maintained Illumination at ambient conditions - 500 lux

b) Average Maintained Illumination - Task Focus:

   i) Exam: 1000 lux on exam table

   ii) In specialized areas such as ophthalmic, ear, nose, and throat (ENT), as well as micro-surgery, lower levels of general illuminance are typically required. This is because these procedures often demand precise visual acuity and the ability to focus on intricate details. Recommended illuminance levels for these areas range between 10 to 50 lux. Dimming capabilities become particularly valuable in operating theaters to accommodate the varying needs of different procedures. The ability to adjust the lighting levels allows for flexibility in supporting multi-functional use of the space. Dimming systems enable surgeons and medical staff to tailor the lighting conditions to their specific requirements, ensuring optimal visibility and precision during delicate procedures. By providing lower levels of general illuminance and incorporating dimming functionality, ophthalmic, ENT, and micro-surgery areas

can be equipped with lighting systems that enhance visual acuity and support the specialized tasks performed in these settings.

iii) Charting - 300 lux on desk

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500º K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.1.1 *Design approach*

Lighting in hospitals and healthcare facilities serves two primary functions, as mentioned here under:

a) Task requirements and visual performance — Adequate lighting is crucial to meet the specific task requirements in different areas of a healthcare facility. Certain activities, such as surgery, medical examinations, and diagnostic procedures necessitate high levels of visual performance. Accurate lighting helps healthcare professionals carry out their duties effectively, ensuring patient safety and optimal outcomes.

b) Creating a visually satisfying and emotionally compatible environment — Lighting has a significant impact on human emotions and feelings of well-being. A well- designed lighting scheme can contribute to a positive and supportive atmosphere within a healthcare facility. Patients, staff and visitors often experience stress and anxiety in such settings and appropriate lighting can help alleviate these feelings. Comfortable and visually pleasing environments promote a sense of calm which is beneficial for patients' recovery and overall well-being.

Additionally, good lighting plays a role in enhancing the perception of quality and competence within a hospital. Well-lit spaces convey a sense of professionalism, cleanliness, and attention to detail. Patients and visitors are more likely to have confidence in the facility and its staff when they perceive the environment as well-maintained and thoughtfully designed.

In summary, lighting in hospitals and healthcare facilities is not only essential for meeting task requirements and ensuring visual performance but also crucial for creating a comforting, emotionally supportive environment. By considering both functional and aesthetic aspects of lighting design, healthcare facilities can contribute to the well-being and satisfaction of patients, staff, and visitors.

When designing the lighting for hospitals, several factors need to be considered to ensure optimal functionality and user experience. Some of these factors include:

a) *Daylight* — Incorporating natural daylight and access to windows is highly beneficial for patients, as it provides a connection to the outside world and improves their well-being.

However, measures should be taken to control sun penetration and prevent discomfort. Adjustable blinds can be installed to regulate daylight and limit its impact during nighttime when patient sleep may be disrupted. Additionally, if daylight contributes significantly to the overall lighting, an automatic switching or dimming system can be implemented to avoid energy wastage.

b) *Lines of sight* — In hospitals, patients often have specific lines of sight towards the ceiling and upper parts of the opposite walls. It is important to design the lighting in a way that minimizes glare for patients while ensuring good visibility for doctors and nurses. Careful selection and positioning of light fixtures can help achieve this balance.

c) *Colour rendering requirements* — Accurate colour rendering is crucial in clinical areas of hospitals such as ward units, consulting rooms and operating departments. Different colors of skin, eyes, tissues and fluids can provide important diagnostic and treatment information. Therefore, light sources used in these areas should meet strict colour rendering requirements. A minimum CIE general colour rendering index (CRI) of Ra80 is recommended for most clinical areas, while specialist areas may require a higher CRI of Ra90. It is essential to avoid using light sources with different color rendering or temperature characteristics within the same area.

d) *Flexibility in ward lighting* — Hospital wards face a challenge during night time when patients need to sleep but staff members require sufficient visibility to perform their tasks safely and efficiently. Ward lighting should be designed with flexibility in mind. This can be achieved through switching and dimming capabilities. Switching allows for basic control while dimming provides finer flexibility enabling adjustment of light levels based on specific requirements.

By taking these factors into account, the lighting design in hospitals can effectively support the needs of patients, healthcare professionals, and staff members while promoting a comfortable and visually appropriate environment.

5.1.1.2 *Controls*

a) Multi-level switching and dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control devices for all lightings. Automatic daylight response by photo controls for ambient lighting.
c) Under-cabinet lights shall be controlled with integral switch.
d) Provide separate controls for areas enclosed by curtains.

5.1.1.3 *Additional requirements*

Isolation and infection control examination and treatment rooms shall be specified with enclosed and sealed luminaires, IP Rated 65/ UL listed for wet locations and can be wiped down with corrosive cleaners.

5.1.2 *Blood Draw Station Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux
b) Average Maintained Illumination - Task / Focus: Blood Draw: 1000 lux at blood draw site
c) Uniformity Ratio (max / min):
    i) Ambient - 5:1
    ii)Blood Draw Site - 2:1
d) Correlated Color Temperature (CCT) for LED - 3500º K
e) Color Rendering Index (CRI) for LED ≥ 80

5.1.2.1 *Design approach*

A combination of ambient and task illumination should be provided to reach desired illumination levels. Both horizontal and vertical illumination is important for blood draw rooms, specifically at blood draw chair.

5.1.2.2 *Control*

a) Multi-level dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control devices for all luminaires.
c) Automatic daylight response by photocontrols for ambient lighting.
d) Under-cabinet lights shall be controlled with integral switch.
e) Provide separate controls for areas enclosed by curtains.

5.1.3 *Orthotic and Casting Room Design Parameters*

a) Average Maintained Illumination at Ambient - 300 lux
b) Average Maintained Illumination - Task / Focus
    i)Bench Top - 500 lux at 915mm AFF (Above finished floor level)
    ii) Fine Detail - 1000 lux at 915mm AFF (Above finished floor level)
c) Uniformity Ratio (max / min) at Ambient - 3:1.
d) Correlated Color Temperature (CCT) for LED - 3500º K
e) Color Rendering Index (CRI) for LED ≥ 80

5.1.3.1 *Design approach*

When designing the lighting for an orthotic and casting room, the following aspects should be considered:

a) *Task lighting* — The primary focus in an orthotic and casting room is to ensure proper visibility for the medical professionals conducting procedures and treatments. Task lighting should be the main consideration, providing bright and localized illumination in the specific areas where orthotic and casting procedures take place. This could include workstations, examination tables or casting stations. Adjustable and directional lighting fixtures such as adjustable spotlights or task lights can be used to ensure optimal lighting conditions during procedures.

b) *Uniform illumination* — It is important to ensure uniform illumination throughout the orthotic and casting room avoiding any harsh shadows or areas with insufficient lighting. This can be achieved by using a combination of general overhead lighting and task lighting. Uniform illumination helps the medical professionals accurately assess and work on the patients' conditions ensuring quality treatment outcomes.

c) *Color rendering* — Accurate color rendering is crucial in orthotic and casting rooms as it enables healthcare professionals to accurately assess skin tone, color changes and other visual cues. High color rendering index (CRI) light sources should be utilized to ensure true color representation. A minimum CRI of Ra80 is recommended although higher CRI values are desirable for more precise color differentiation.

d) *Patient comfort* — Consideration should also be given to the comfort of the patients during their time in the orthotic and casting room. Lighting should be designed to create a soothing and calming atmosphere. Avoiding glare and harsh lighting can help minimize patient discomfort and anxiety. Indirect or diffused lighting can be used to create a gentler and evenly distributed illumination.

e) *Energy efficiency* — Implementing energy-efficient lighting solutions is important in healthcare facilities. Using LED lighting fixtures is recommended due to their energy efficiency, long lifespan, and adjustable dimming capabilities. Dimmable lighting systems can provide flexibility in adjusting light levels according to specific tasks, promoting energy savings and reducing overall operational costs.

By incorporating task lighting, uniform illumination, accurate color rendering, patient comfort considerations, and energy-efficient lighting solutions, the lighting design in orthotic and casting rooms can enhance the visibility and comfort for medical professionals and patients alike.

5.1.3.2 *Controls*

Implementing appropriate lighting controls in hospital lighting systems is essential for energy efficiency, flexibility and user convenience. Here are some common lighting controls used in hospital lighting:

a) Multi-level dimming controls for LED luminaires — LED luminaires often come with dimming capabilities. Multi-level dimming controls allow for adjusting the light output to different levels, providing flexibility in meeting various lighting needs throughout the day. Dimming controls can be used to create different lighting scenes, such as brighter illumination for procedures or dimmer lighting for patient rest and relaxation.

b) Automatic full OFF or scheduled OFF with local manual control devices — To conserve energy, it is important to have lighting systems automatically turn off when not in use. This can be achieved through automatic full OFF controls, which switch off all lighting fixtures in a specific area or room. Additionally, scheduled OFF controls can be programmed to turn off lighting during specific hours or when certain areas are typically unoccupied. Local manual control devices, such as switches or occupancy sensors can provide users with manual control over the lighting when needed.

c) Automatic daylight response by photocontrols — Photocontrols, such as daylight sensors can be utilized to automatically adjust the artificial lighting levels based on the available natural daylight. These sensors detect the amount of daylight entering a space and dim or turn off artificial lighting accordingly. By utilizing natural light effectively, energy consumption can be reduced while maintaining appropriate illumination levels.

d) Under-cabinet lights controlled with integral switches — Under-cabinet lights, often used in task areas or examination spaces, can be equipped with integral switches. This allows for independent control of these specific lights, giving users the ability to turn them on or off as required for focused lighting on work surfaces.

By incorporating these lighting controls into hospital lighting systems, energy efficiency can be improved, lighting levels can be tailored to specific tasks and needs, and user convenience can be enhanced. It is important to consider the unique requirements of different areas within the hospital and select appropriate control strategies accordingly.

5.1.3.3 *Additional requirement*

In addition to the previous requirements, there are additional considerations for hospital lighting:

a) *Supplemental medical procedure lights* — Certain rooms in a hospital such as operating rooms, examination rooms or treatment rooms may require specialized supplemental medical procedure lights. These lights are designed to provide focused and adjustable illumination for specific medical procedures. Their placement and integration with the overall lighting design should be carefully coordinated to ensure optimal functionality and visual comfort.

b) *Coordination with casework and equipment layouts* — The placement of luminaires in hospital rooms should be coordinated with the casework (cabinets, shelves, etc.) and equipment layouts. Lighting fixtures should be strategically positioned to avoid shadows and ensure that critical areas are well-lit. Collaborating with the room's design and equipment teams can help ensure an integrated and efficient layout.

c) *Matching CCT and CRI of supplemental medical lights* — When selecting luminaires for hospital rooms with supplemental medical procedure lights, it is important to ensure that the luminaires' correlated color temperature (CCT) and color rendering index (CRI) match those of the supplemental lights. Consistency in color appearance and rendering is crucial for accurate visual assessment, diagnostics, and medical procedures.

d) *Mitigating glare and veiling reflections* — Proper luminaire placement and optics are essential to mitigate glare and veiling reflections in hospital rooms. Glare can be uncomfortable for patients and medical professionals, and it can hinder accurate visual perception. Optics such as louvers, diffusers, or shields can be employed to control the direction and distribution of light, reducing glare and minimizing veiling reflections on reflective surfaces.

By addressing these additional requirements hospital lighting can be optimized to support medical procedures, minimize visual discomfort, and enhance the overall functionality and safety of healthcare environments. Collaborating with lighting designers, architects, and medical professionals can ensure that lighting solutions are tailored to the specific needs of each room or area within the hospital.

5.1.4 Laboratory Design Parameter

a) Average Maintained Illumination at Ambient - 500 lux
b) Average Maintained Illumination - Task / Focus: Bench Top: 800 lux at 915mm AFF on work Surface. Dental Prosthetics: 2000 lux 915 mm AFF on work surface.
c) Uniformity Ratio (max / min) at Ambient - 3:1
d) Correlated Colour Temperature (CCT) for LED - 3500º K
e) Colour Rendering Index (CRI) for LED ≥ 80

5.1.4.1 *Design approach*

In addition to the previous points, here are further considerations for hospital laboratory design:

a) *Combination of ambient and task illumination* — Hospital laboratories require a combination of ambient lighting to provide overall illumination and task lighting for specific work areas. Ambient lighting should be evenly distributed throughout the

laboratory to ensure adequate visibility and reduce shadows. Task lighting, such as adjustable task lights or under-cabinet lighting, should be provided at workstations and areas that require focused illumination for detailed tasks.

b) *Vertical illumination at shelving* — Proper illumination of shelving units and storage areas is essential in hospital laboratories. Vertical illumination, such as wall-mounted or overhead lighting, should be considered to ensure visibility and accessibility to stored items. Adequate lighting levels and uniformity should be maintained to avoid potential errors or accidents when accessing materials.

c) *Color rendering and temperature* — Accurate color rendering and temperature are particularly important in hospital laboratories. High color rendering index (CRI) luminaires should be used to ensure the true representation of colors, which is crucial for visual assessment, differentiation of samples, and accurate analysis. Additionally, the color temperature of lighting should be carefully selected to match the specific requirements of the laboratory, considering factors such as visual comfort and task requirements.

d) *UV-free or UV-filtered light luminaires* — In cell and tissue labs, where sensitive materials are handled, it is important to provide UV-free or UV-filtered lighting. Ultraviolet (UV) light can have damaging effects on cells and tissues, potentially compromising experimental results. Specialized luminaires with UV-filtering properties or UV-free light sources should be used to ensure the integrity of samples and accurate research outcomes.

By considering a combination of ambient and task lighting, providing vertical illumination at shelving, emphasizing color rendering and temperature, and using UV-free or UV-filtered light luminaires in appropriate laboratory areas, the design of hospital laboratories can support accurate analysis, maintain sample integrity, and provide a safe and productive working environment. Collaboration with lighting experts, laboratory personnel, and relevant stakeholders is crucial to ensure compliance with regulations and best practices in laboratory lighting design.

5.1.4.2 *Controls*

Incorporating appropriate lighting controls is essential for effective and energy-efficient operation of hospital laboratory lighting systems. Here are additional control considerations based on the provided requirements:

a) *Multi-level dimming controls for LED luminaires* — Implementing multi-level dimming controls allows for adjusting the light output of LED luminaires in laboratory spaces. This provides flexibility to meet varying illumination needs during different activities or

procedures. Dimming controls can be used to create different lighting levels based on specific requirements, promoting energy savings and visual comfort.

b) *Manual ON with automatic full OFF or scheduled OFF with local manual control devices* — To ensure energy efficiency and user convenience, a control strategy that combines manual ON control with automatic full OFF or scheduled OFF control should be employed. This allows users to manually turn on lighting when needed using local control devices, while ensuring lights automatically turn off during unoccupied periods or according to a predetermined schedule. Manual control devices can include switches or occupancy sensors.

c) *Automatic daylight response by photocontrols for ambient lighting* — Installing photocontrols, such as daylight sensors, enables automatic adjustment of ambient lighting based on the available natural daylight. These sensors detect daylight levels and adjust the artificial lighting accordingly. By utilizing natural light effectively, energy consumption can be reduced while maintaining appropriate illumination levels.

d) *Under-cabinet lights controlled with integral switches* — Under-cabinet lights, commonly used in laboratory workspaces, should be equipped with integral switches. This allows users to independently control these specific lights, providing focused illumination on work surfaces as required. Integral switches provide convenience and flexibility without affecting the operation of other lighting systems.

e) *Motion detectors in every aisle for complete* coverage — If sensors are used in the laboratory, such as occupancy sensors, it is important to ensure complete coverage by placing motion detectors in every aisle. This ensures that lighting is activated when movement is detected in any part of the laboratory, maintaining adequate illumination levels while conserving energy in unoccupied areas.

f) *Dimmers for laboratories using specialized equipment* — Laboratories that utilize photographic or optical diagnostic techniques or employ electron microscopes may require precise control over lighting levels. Installing dimmers allows for adjusting the intensity of light to meet specific requirements and minimize potential interference or artifacts caused by excessive lighting. Dimming controls offer fine-tuned lighting adjustments in these specialized laboratory spaces.

By incorporating these lighting controls into hospital laboratory lighting systems, energy efficiency can be maximized, lighting levels can be tailored to different tasks, and user convenience can be enhanced. Collaboration with lighting designers, laboratory staff, and relevant stakeholders is essential to ensure that the control strategies align with the specific needs of the laboratory environment and comply with regulatory requirements.

5.1.4.3 *Specific requirement*

a) Consider light sources with higher CRI ≥ 95 and CCT for critical color rendering tasks.

5.1.5 *Procedure Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux
b) Average Maintained Illumination - Task / Focus: Medical Task: 10000 lux surgical task lighting. Control Room: 300 lux at finished floor. System Component: 100 lux at finished floor
c) Uniformity Ratio (max / min) at Ambient - 3:1
d) Correlated Color Temperature (CCT) for LED - 3500º K
e) Color Rendering Index (CRI) for LED ≥ 90

5.1.5.1 *Design approach*

When designing hospital rooms, such as patient rooms or procedure rooms, the following approach can be taken to ensure optimal lighting:

a) Combination of ambient and task illumination — Hospital rooms require a combination of ambient and task lighting to achieve the desired illumination levels. Ambient lighting provides overall illumination and creates a comfortable environment, while task lighting focuses on specific areas where detailed tasks are performed. By combining these two types of lighting, the room can be properly illuminated for various activities and functions.

b) Horizontal and vertical illumination for procedure rooms — Procedure rooms, where medical interventions or examinations take place, should have both horizontal and vertical illumination. Horizontal illumination ensures that the working surface or patient area is evenly illuminated, allowing medical professionals to perform procedures with precision. Vertical illumination, such as wall-mounted lights or indirect lighting, helps minimize shadows and provides additional lighting for the room.

c) Visually comfortable luminaires with appropriate optics — It is crucial to choose visually comfortable luminaires with appropriate optics to minimize glare during procedures, especially when the patient is in a reclining position. Glare can be distracting, uncomfortable, and may hinder accurate visual assessment. Luminaires with glare-reducing features, such as diffusers or shields, should be selected to ensure a comfortable and visually optimized environment for both patients and medical professionals.

Additionally, it is important to consider the specific requirements of different hospital rooms. For example, patient rooms may benefit from adjustable lighting fixtures or bedside reading lights to provide individualized lighting options for patients. Specialized rooms, such as intensive care units (ICUs) or operating rooms, may have specific lighting regulations and standards that need to be followed to ensure patient safety and optimal working conditions for medical staff.

By considering a combination of ambient and task lighting, incorporating horizontal and vertical illumination in procedure rooms and selecting visually comfortable luminaires with appropriate optics, the design approach for hospital rooms can enhance visibility, comfort and overall functionality. Collaboration between lighting designers, healthcare professionals, and architects is crucial to ensure that the lighting design meets the specific needs and regulations of the healthcare facility.

5.1.5.2 *Controls*

In hospital rooms, incorporating effective lighting controls is essential to enhance energy efficiency, user convenience, and overall functionality. Here are some recommended control strategies for hospital room lighting:

a) *Multi-level dimming controls for LED luminaires* — Utilizing multi-level dimming controls for LED luminaires allows for adjusting the light output to different levels. This enables flexibility in creating desired lighting scenes and accommodating various activities or preferences in hospital rooms. Dimming controls can be used to achieve different lighting intensities for tasks, relaxation, or nighttime lighting, promoting energy savings and creating a comfortable environment.

b) *Automatic full OFF or scheduled OFF with local manual control devices* — Implementing automatic full OFF or scheduled OFF control with local manual control devices ensures efficient energy management in hospital rooms. Lighting can be automatically turned off during unoccupied periods or based on predetermined schedules, reducing unnecessary energy consumption. Local manual control devices, such as switches or keypads, allow users to override the automatic controls when needed.

c) *Under-cabinet lights controlled with integral occupancy sensors or switches* — Controlling under-cabinet lights with integral occupancy sensors or switches in hospital rooms provides convenience and energy efficiency. Occupancy sensors detect the presence or absence of occupants and automatically turn the lights on or off accordingly. This eliminates the need for manual control and helps conserve energy when the area is

unoccupied. Alternatively, integral switches can be used to provide direct user control over under-cabinet lights.

By incorporating these lighting controls, hospital rooms can benefit from improved energy efficiency, customized lighting levels, and ease of use. It is important to collaborate with lighting designers, facility managers, and healthcare professionals to determine the specific control requirements and ensure compliance with applicable regulations and standards.

5.1.5.3 *Specific requirements*

In addition to the previous points, here are further specific requirements for hospital room lighting:

a) Supplemental medical procedure lights — Some hospital rooms, such as examination or treatment rooms, may require supplemental medical procedure lights. These lights are designed to provide focused and adjustable illumination for specific medical procedures. It is crucial to coordinate the placement of these lights with the casework and equipment layouts in the room to ensure optimal positioning and functionality during medical procedures.

b) Matching CCT and CRI with supplemental medical lights — Room luminaires should be carefully selected to match the correlated color temperature (CCT) and color rendering index (CRI) of the supplemental medical lights. This consistency in color temperature and color rendering ensures that the lighting across the room is uniform and harmonious. It also facilitates accurate visual assessment and differentiation of colors during medical procedures.

c) Isolation and infection control requirements — In isolation and infection control examination and treatment rooms, special considerations should be given to the luminaires. These luminaires should be enclosed and sealed to prevent the ingress of dust, moisture, or contaminants. They should have a minimum IP (Ingress Protection) rating of 65, which ensures their resistance to water and dust intrusion. Additionally, the luminaires should be UL listed for wet locations, indicating their suitability for use in areas where cleaning with corrosive cleaners is necessary.

d) Higher CRI and CCT for critical color rendering tasks — In certain hospital rooms where critical color rendering tasks are performed, such as in operating rooms or pathology labs, it is important to consider light sources with higher CRI (e.g., CRI = 95) and appropriate

CCT. High CRI ensures accurate and reliable color representation, which is crucial for precise visual assessment and diagnosis. Additionally, selecting the appropriate color temperature (CCT) can enhance visibility and clarity in these critical tasks.

By addressing these specific requirements, hospital room lighting can be tailored to meet the unique needs of medical procedures, infection control measures, and critical color rendering tasks. Collaboration between lighting designers, healthcare professionals, and relevant stakeholders is crucial to ensure compliance with regulations, standards, and best practices in hospital lighting design.

5.1.6 *Diagnostic Imaging Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux at 900 mm AFF
b) Average Maintained Illumination - Task / Focus: Control Station: 300 lux at finished floor. System Component: 200 lux at finished floor. Patient Screening: 400 lux at finished floor
c) Uniformity Ratio (max / min):

i)Ambient 3:1 in imaging and control rooms

ii) Ambient 4:1 during imaging

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.6.1 *Design approach*

When designing diagnostic imaging rooms, such as MRI rooms or X-ray rooms, the following approach can be taken to ensure optimal lighting:

a) *Combination of ambient and task illumination* — Diagnostic imaging rooms require a combination of ambient and task lighting to achieve the desired illumination levels. Ambient lighting provides overall illumination and creates a comfortable environment for both caregivers and patients. Task lighting focuses on specific areas where detailed tasks are performed, such as reading diagnostic images or operating equipment. By combining these two types of lighting, the room can be properly illuminated for both caregiver performance and patient comfort.

b) *Horizontal and vertical illumination* — Both horizontal and vertical illumination are important in diagnostic imaging rooms. Horizontal illumination ensures that the working surfaces and diagnostic equipment are evenly and adequately lit, allowing caregivers to perform their tasks accurately. Vertical illumination, such as wall-mounted lights or

indirect lighting, helps create a visually comfortable environment for patients, reducing the perception of harsh lighting and enhancing their comfort during procedures.

c) *Visually comfortable luminaires with appropriate optics* — It is important to select visually comfortable luminaires with appropriate optics to minimize glare, especially when the patient is in a reclining position during imaging procedures. Glare can be distracting and uncomfortable, affecting both caregiver performance and patient experience. Luminaires with appropriate optics, such as diffusers or anti-glare features, should be used to create a well-lit environment without causing discomfort or visual disturbances.

d) *Graphic and decorative luminaires* — In imaging rooms, incorporating graphic and decorative luminaires can add visual interest and enhance the overall ambiance. These luminaires can be used as decorative elements or to create visual focal points, providing a more aesthetically pleasing environment during testing. However, it is important to ensure that the graphic or decorative elements do not interfere with the functionality of the imaging equipment or cause any distractions for the caregivers.

By considering a combination of ambient and task lighting, incorporating horizontal and vertical illumination, selecting visually comfortable luminaires, and optionally incorporating graphic and decorative luminaires, the design approach for diagnostic imaging rooms can enhance visibility, comfort, and create an engaging environment for both caregivers and patients. It is important to collaborate with lighting designers, healthcare professionals, and equipment manufacturers to ensure compliance with safety and performance requirements specific to diagnostic imaging environments.

5.1.6.2 *Controls*

When it comes to controls in MRI rooms or X-ray rooms, the following strategies can be implemented:

a) *Fully dimmable imaging and control rooms* — It is essential to have fully dimmable lighting in MRI rooms or X-ray rooms. This allows the level of illumination to be adjusted to the specific requirements of each imaging procedure, ensuring optimal visibility and comfort for both patients and healthcare professionals. Dimming controls can be used to regulate the light output and create the desired lighting conditions.

b) *Automatic full OFF or scheduled OFF with local manual control devices* — Implementing automatic full OFF or scheduled OFF controls with local manual control devices ensures energy efficiency and convenience. Lighting can be automatically turned off when the room is not in use or based on predetermined schedules, reducing energy consumption and promoting sustainability. Local manual control devices, such as switches or keypads, provide the flexibility for users to override the automatic controls as needed.

c) *Under-cabinet lights controlled with integral occupancy sensors or switches* — Controlling under-cabinet lights with integral occupancy sensors or switches enhances energy efficiency

and user convenience. Occupancy sensors detect the presence or absence of occupants and automatically turn the lights on or off accordingly, eliminating the need for manual control. Alternatively, integral switches can be used to provide direct user control over the under-cabinet lights.

By incorporating these control strategies, MRI rooms and X-ray rooms can benefit from efficient energy management, customized lighting levels, and ease of use. It is important to work closely with lighting designers, facility managers, and healthcare professionals to ensure compliance with relevant regulations and safety standards specific to imaging environments.

5.1.6.3 *Specific requirement*

In addition to the previous points, there are specific requirements for lighting in MRI and X-ray rooms:

a) *Non-ferrous materials in EMI and RFI fields* — In imaging rooms where there are electromagnetic (EMI) and radio frequency (RFI) fields, it is crucial to use light fixtures made with non-ferrous materials. Ferrous materials can be affected by the magnetic fields and may cause interference or distortions in the imaging results. By using non-ferrous materials, such as non-magnetic alloys or non-conductive materials, the lighting fixtures can minimize any potential interference. Furthermore, the LED drivers for the lighting fixtures should be located outside of the magnetic resonance field. Typically, these drivers are placed in the system component room or control room, away from the immediate vicinity of the MRI machine. Additionally, providing electrical noise filters for the LED drivers can help reduce any electrical noise or interference that might affect the imaging equipment.

b) *Avoid placing luminaires over large scanning equipment* — It is important to avoid placing luminaires directly over large scanning equipment, such as MRI machines or X-ray machines. These machines often have specific clearance requirements and positioning guidelines to ensure their proper functionality and safety. Placing luminaires directly over such equipment may interfere with the machine's operations or obstruct access for maintenance and servicing.

By following these specific requirements, the lighting design in MRI and X-ray rooms can be optimized to minimize interference with the imaging equipment and ensure the safety and accuracy of the diagnostic procedures. Collaborating with lighting designers, medical imaging professionals, and facility managers is essential to ensure compliance with applicable regulations and guidelines specific to these imaging environments.

5.1.7 *Diagnostic testing room design parameters*

a) Average Maintained Illumination at Ambient - 500 lux at 900 mm AFF

b) Uniformity Ratio (max / min) at Ambient - 3:1

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

5.1.7.1 *Design approach*

When designing diagnostic testing rooms, specific considerations can be made for different types of testing rooms, such as ophthalmology testing rooms. Here are additional aspects to consider:

a) *Dimming controls for ophthalmology testing rooms* — Ophthalmology testing rooms often require low lighting levels due to procedures involving the dilation of patients' eyes and the use of specialized equipment. Providing dimming controls for the lighting in these rooms is crucial. Dimmable luminaires or adjustable lighting systems allow healthcare professionals to customize the lighting levels according to the specific requirements of each examination or procedure. This flexibility ensures patient comfort and enables accurate test results.

b) *Optics to minimize glare during examinations* — Glare can significantly impact the accuracy of diagnostic testing, especially when patients are in a reclining position. Careful selection of luminaires with appropriate optics, such as diffusers or baffles, helps to minimize glare and distribute the light evenly across the examination area. This ensures that healthcare professionals can perform examinations with optimal visual comfort and precision.

c) *Consideration of specialized equipment* — Different diagnostic testing rooms may require specific equipment that has unique lighting requirements. For example, in ophthalmology testing rooms, specialized equipment like slit lamps or retinal cameras may need specific lighting conditions. Collaboration with equipment manufacturers and healthcare professionals can help ensure that the lighting design meets the requirements of the equipment, resulting in accurate and reliable diagnostic results.

By incorporating these design approaches, diagnostic testing rooms can provide appropriate illumination levels, minimize glare, and cater to the specific needs of different types of examinations. It is important to work closely with lighting designers, healthcare professionals, and equipment specialists to ensure compliance with industry standards and guidelines specific to each type of diagnostic testing room.

5.1.7.2 *Control*

a) Lights must be fully dimmable for patient comfort and relaxation during testing.

b) Automatic full OFF or scheduled OFF and local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.
d) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

5.1.8 Chemotherapy Treatment Room Design Parameters

a) Average Maintained Illumination at Ambient - 200 lux at AFF

b) Average Maintained Illumination - Task / Focus:
    i) Task (Injections) - 500 lux at 900 mm AFF

    ii) Agent Preparation - 1000 lux at 900mm AFF

c) Uniformity Ratio (max / min) at Ambient - 3:1
d) Correlated Color Temperature (CCT) for LED - 3500° K
e) Color Rendering Index (CRI) for LED ≥ 80

5.1.8.1 *Design approach*

When designing chemotherapy treatment rooms, the following design approach can be considered:

a) *Combination of ambient and task illumination* — Chemotherapy treatment rooms require a combination of ambient and task lighting to achieve the desired illumination levels. Ambient lighting provides general illumination throughout the room, creating a comfortable and inviting environment. Task lighting focuses on specific areas where medical procedures or tasks are performed, such as administering medication or accessing patient records. The combination of these lighting types ensures that healthcare professionals have adequate visibility while also providing a soothing atmosphere for patients.

b) *Horizontal and vertical illumination* — Both horizontal and vertical illumination should be considered in chemotherapy treatment rooms. Horizontal illumination refers to the lighting that illuminates the working surfaces, such as treatment carts or medication preparation areas. Vertical illumination ensures that the walls and surrounding areas are well-lit, creating a visually balanced and pleasant environment. Adequate lighting in both horizontal and vertical directions helps create a sense of openness and reduces visual discomfort.

c) *Minimization of glare* — Chemotherapy treatment rooms should be designed with luminaires that are visually comfortable and equipped with appropriate optics to minimize glare. Glare can cause visual discomfort and affect the well-being of both patients and healthcare professionals, especially when patients are in a reclining position during treatment. The use of fixtures with diffusers, shields, or glare-reducing optics can help control direct glare and create a more comfortable and visually pleasing environment.

d) *Color rendering and temperature* — Color rendering and color temperature are particularly important in chemotherapy treatment rooms. Color rendering refers to the ability of the lighting to accurately render colors, which is crucial for visual assessments, identifying veins for intravenous procedures, and creating a calming atmosphere. High color rendering index (CRI) luminaires should be used to ensure accurate color representation. Color

temperature, which refers to the perceived warmth or coolness of the light, can also influence the overall ambiance. Selecting a color temperature that promotes a soothing and supportive atmosphere is beneficial for patients during their treatment.

By considering a combination of ambient and task lighting, horizontal and vertical illumination, glare reduction, and appropriate color rendering and temperature, the design of chemotherapy treatment rooms can enhance the comfort and well-being of patients and healthcare professionals. Collaborating with lighting designers, healthcare providers, and patients can help ensure that the lighting design meets the specific needs and preferences of the chemotherapy treatment environment.

5.1.8.2 *Specific requirements*

In addition to the design approach mentioned earlier, specific requirements for chemotherapy treatment rooms include:

a) *Mitigation of light spill* — It is important to minimize light spill from common areas into patient areas in chemotherapy treatment rooms. Light spill can create distractions and discomfort for patients undergoing treatment. Design considerations should include appropriate shielding and light control measures to ensure that the lighting is directed primarily towards the intended areas and does not cause unnecessary illumination in patient areas.

b) *Pillow switch lighting control* — Providing a pillow switch lighting control system allows patients to have control over their immediate lighting environment. This feature allows patients to adjust the lighting level or turn the lights on and off according to their comfort and preference. Pillow switch controls can enhance patient autonomy and contribute to a more personalized and patient-centered experience.

c) *Lighting in chemotherapy agent preparation areas* — Chemotherapy agent preparation areas require special attention in terms of lighting design. The luminaires used in these areas should be specifically designed to be enclosed and sealed, meeting IP rating 65 (minimum) and UL listing for wet locations. This ensures that the luminaires can withstand the use of corrosive cleaners for regular cleaning and maintenance. Compliance with relevant standards, such as those specific to healthcare facilities and hazardous material handling, is crucial to ensure the safety and proper functioning of the lighting system in these areas.

By addressing the specific requirements of mitigating light spill, providing pillow switch lighting control, and ensuring appropriate lighting for chemotherapy agent preparation areas, the design of chemotherapy treatment rooms can create a safe, comfortable, and patient-centric environment. Collaboration between lighting designers, healthcare professionals, and facility managers is essential to meet these requirements and ensure compliance with relevant standards and guidelines.

5.1.9 *Radiation Therapy Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lx

b) Uniformity Ratio (max / min):

    i) Ambient - 3:1

    ii) Ambient - 4:1 during treatment

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

5.1.9.1 *Design approach*

When designing a radiation therapy room, it is crucial to consider the following design approaches:

a) *Radiation shielding* — Radiation therapy rooms necessitate meticulous shielding to safeguard the well-being of both patients and staff. This entails using suitable materials like lead or concrete to contain the radiation within the treatment area. The shielding must encompass the walls, floors, and ceilings. It's crucial to collaborate closely with radiation safety experts during the design phase to meet regulatory requirements and ensure optimal protection.

b) *Illumination levels* — Adequate illumination levels are essential in radiation therapy rooms to provide a safe and efficient working environment for healthcare professionals. A combination of ambient and task lighting should be considered to meet the desired illumination levels. Task lighting is particularly important to provide focused illumination in areas where precise procedures are performed. Collaborating with radiation therapy experts and lighting designers will help determine the appropriate lighting levels for different areas within the room.

c) *Visual comfort and glare reduction* — Luminaires in radiation therapy rooms should be designed to provide visual comfort for both patients and healthcare professionals. Properly designed optics, such as diffusers and shields, can help minimize glare and provide even illumination across the treatment area. Glare reduction is especially important as patients may be in reclining positions during treatment sessions. Optimal lighting conditions contribute to patient comfort and allow healthcare professionals to perform procedures accurately.

d) *Integration with treatment equipment* — Radiation therapy rooms often contain specialized treatment equipment, such as linear accelerators. The lighting design should consider the integration of lighting fixtures with the treatment equipment to avoid interference or

shadows that may affect treatment precision. Collaboration with equipment manufacturers and integration specialists is crucial to ensure proper coordination between lighting and treatment equipment.

e) *Emergency lighting and backup power* — Radiation therapy rooms should have appropriate emergency lighting systems in place to ensure safe evacuation in case of power outages or emergencies. Backup power systems, such as uninterruptible power supplies (UPS) or generators, should be considered to ensure continuous operation of critical lighting and equipment during power disruptions.

f) *Regulatory compliance* — Radiation therapy rooms must comply with specific regulations and guidelines pertaining to radiation safety, electrical codes, and healthcare facility requirements. It is important to work closely with radiation safety officers, regulatory bodies, and design professionals to ensure compliance with all applicable standards and regulations.

By considering radiation shielding, proper illumination levels, visual comfort, integration with treatment equipment, emergency lighting, and regulatory compliance, the design of radiation therapy rooms can create a safe and efficient environment for both patients and healthcare professionals. Collaboration among radiation safety experts, lighting designers, and other stakeholders is crucial to ensure a successful and compliant design.

5.1.9.2 *Controls*

a) Provide patient bed/chair control for lighting in treatment rooms or cubicles.

b) Dimming controls, a must for patient comfort.

c) Automatic full OFF or scheduled OFF with local manual control devices.

d) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

5.1.9.3 *Specific requirements*

a) Pillow switch lighting control needs to provide for patient use.

b) Luminaire placement and optics should mitigate glare and veiling reflections.

5.1.10 *Dialysis Treatment Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux at 900 mm AFF

b) Average Maintained Illumination - Task / Focus:

i)Needle Insertion - 2000 lux at site (procedure light)

ii)1qSystem Component - 100 lux at finished floor

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.10.1 *Design approach*

When designing a dialysis treatment room, the following design approaches should be considered:

a) *Combination of ambient and task illumination* — Dialysis treatment rooms require a combination of ambient and task lighting to achieve the desired illumination levels. Ambient lighting provides overall illumination throughout the room, while task lighting focuses on specific areas where procedures are performed. Both horizontal and vertical illumination should be considered to ensure adequate lighting coverage in different parts of the room.

b) *Visual comfort and glare reduction* — Luminaires in dialysis treatment rooms should be designed to provide visual comfort for both patients and healthcare professionals. Appropriate optics, such as diffusers and shields, can help minimize glare and provide uniform illumination across the treatment area. It is important to consider the reclining position of patients during procedures and ensure that lighting fixtures do not cause discomfort or unwanted reflections.

c) *Color rendering and temperature* — Color rendering and temperature play a significant role in the visual perception of the dialysis environment. High color rendering index (CRI) is important to accurately represent colors, especially when assessing the condition of blood during treatment. The color temperature of the lighting should also be considered to create a visually comfortable and welcoming atmosphere for patients.

By considering a combination of ambient and task lighting, visual comfort and glare reduction, and appropriate color rendering and temperature, the design of dialysis treatment rooms can create a comfortable and efficient environment for both patients and healthcare professionals. Collaborating with lighting designers, healthcare staff, and facility managers will help ensure that the lighting design meets the specific needs of the dialysis treatment setting.

5.1.10.2 *Control*

a) Multi-level dimming controls for LED luminaires.

b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.

d) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

5.1.10.3 *Specific requirement*

a) Luminaire placement and optics should mitigate glare and veiling reflection especially in areas with pools.

b) Luminaires in rooms with whirlpools, Hubbard tanks, and pools shall be enclosed and sealed and IP 65/ UL listed for wet locations.

5.1.11 *Audiology Testing Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux

b) Average Maintained Illumination - Task / Focus -
   i) Control Booth - 300 lux

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 90

5.1.11.1 *Physical/occupational therapy*

a) Average Maintained Illumination at Ambient - 100 lux at finished floor

b) Average Maintained Illumination - Task / Focus:
   i) Clinics - 500 lx at 900mm AFF
   ii) Arm and Leg Whirlpools - 300 lux at 600 mm AFF
   iii) Hubbard Tanks - 300 lux) at 600 mm AFF
   iv) Hydrotherapy - 300 lux at 600 mm AFF
   v) Special Treatment - 750 lux at 900 mm AFF
   vi) Tables and Exercise - 300 lux at 900 mm AFF
   vii) Food Preparation - 500 lux at 900 mm AFF

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering (CRI) for LED - minimum 80 or above.

5.1.11.2 *Surgery/operating room lightning design parameters*

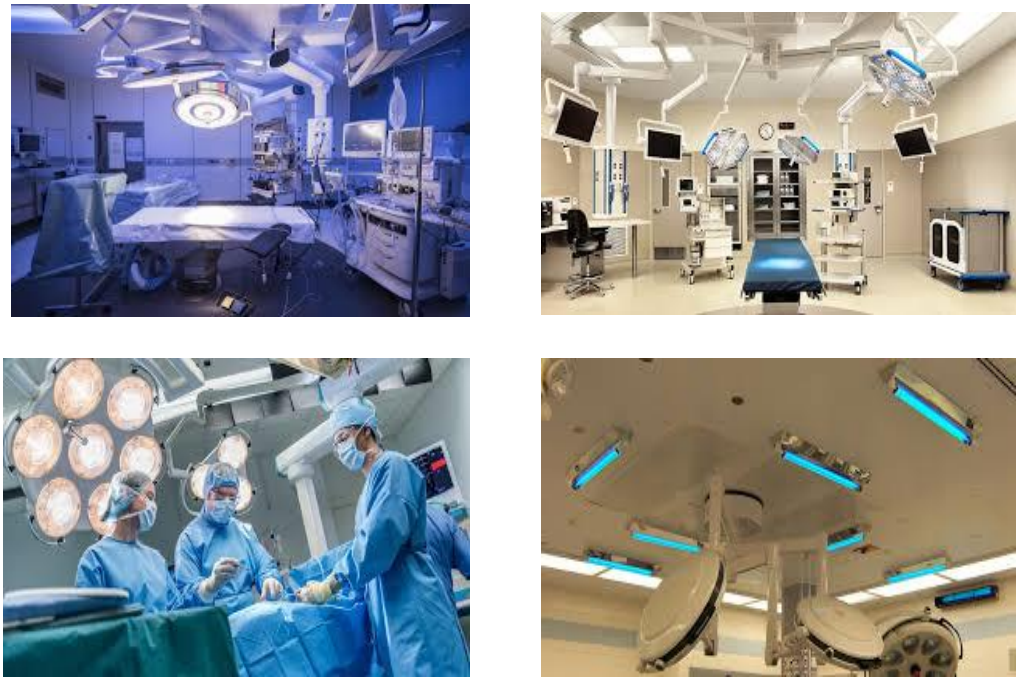

Fig. 3 Illumination in Surgery/Operating Room

a) Average Maintained Illumination at Ambient - 2000 lux at 900 mm

b) Average Maintained Illumination - Task / Focus:

   i) Setup/Cleanup -1000 lux at 900 mm AFF

   ii) Table - 3000 lux at 900 mm. AFF, dimmable

   iii) Surgical Field - 15000 lux, surgical task light

   iv) Control Room - 500 lux

c) Uniformity Ratio (max / min):

   i)Ambient - 2:1

   ii) Setup/Cleanup - 3:1

d) Correlated Color Temperature (CCT) for LED - 4000° K, or matching the surgical light CCT.

e) Color Rendering Index (CRI) for LED: minimum of 95 and minimum R9 of 95.

NOTE — Power Source: Normal Each luminaire above the surgery table shall be designed with 50% integral emergency power battery packs and connected to Central battery system.

5.1.11.3 *Design approach*

a) A combination of ambient, surgery and task illumination should be provided to reach desired illumination levels as shown in Fig. 3. The use of fully dimmable lighting luminaires provides medical staff with the flexibility required for procedures.

b) Color rendering and temperature are extremely important.

5.1.11.4 *Control*

a) All lighting shall be fully dimmable to provide flexibility during preparation, procedures and clean-up.

b) Coordinate location of room and medical equipment light control stations and provide station at door.

c) Automatic full OFF or scheduled OFF with local manual control devices for all Lighting.

5.1.11.5 *Additional requirements*

a) Operating rooms require surgical lights and they should be in coordination with the casework placements and equipment layouts.

b) Room light luminaires must match the CCT and CRI of surgical lights.

c) Luminaires shall be enclosed and sealed, IP65 (minimum) /UL listed for wet locations and have the ability to be wiped down with corrosive cleaners.

d) Luminaires shall meet the requirements for Electromagnetic Interference/Compatibility (EMI), and Radio Frequency Interface (RFI).

5.1.12 *Surgical Corridor and Scrub*

5.1.12.1 *Area design parameters*

a) Average Maintained Illumination at Ambient - 500 lux at finished floor

b) Average Maintained Illumination - Task / Focus:

   i)Scrub Area - 1000 lux (100 FC) at 900 mm. AFF on scrub sink

c) Uniformity Ratio (max / min) at Ambient - 6:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.12.2 *Controls*

a) Automatic full or partial OFF or scheduled OFF with local manual control devices for all lighting.

b) Automatic daylight response by photocontrols for ambient lighting.

5.1.12.3 *Additional requirements*

a) Luminaires shall be enclosed and sealed, IP65/UL listed for wet locations and have the ability to be wiped down with corrosive cleaners.

5.1.13 *Pre-Operative And Post-Anesthetic Care (Pacu) Design Parameters*

a) Average Maintained Illumination at Ambient - 100 lux at 900 mm AFF

b) Average Maintained Illumination - Task / Focus:

    i)Observation - 500 lux at 900 mm AFF

    ii)Examination - 1000 lux at 900 mm AFF on patient bed

c) Uniformity Ratio (max / min):

    i)Ambient - 5:1

    ii)Exam - 2:1 on patient bed

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.13.1 *Design approach*

a) A combination of ambient and task illumination should be provided to reach desired illumination levels. Both horizontal and vertical illumination is important for caregiver performance and patient comfort.

b) Luminaires should be visually comfortable with appropriate optics to minimize glare during examinations when the patient is in a reclining position.

5.1.13.2 *Controls*

a) General illumination for pre- and post-operative areas should be grouped together and switched at the nurse station.

b) Observation and exam settings should be controlled through switches at the patient headwall.

c) Multi-level switching controls for dimming controls for LED luminaires.

d) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

e) Automatic daylight response by photocontrols for ambient lighting.

5.1.14 Dental Exam And Treatment Room Design Parameters

a) Average Maintained Illumination at Ambient - 500 lux at 900 mm AFF

b) Average Maintained Illumination - Task/Focus: Treatment: 1000 lux at 900 mm. AFF on chair

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 5000° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.14.1 *Design approach*

a) A combination of ambient and task illumination should be provided to reach desired illumination levels. Both horizontal and vertical illumination is important for caregiver performance and patient comfort.

b) Luminaires should be visually comfortable with appropriate optics to minimize glare during examinations when the patient is in a reclining position.

5.1.14.2 *Controls*

a) Multi-level dimming controls for LED luminaires.

b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.

d) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

5.1.14.3 *Additional requirement*

a) Rooms require supplemental medical procedure lights.

b) Lighting needs to be coordinated with casework and equipment layouts.

c) Ensure that room luminaires match the CCT and CRI of supplemental medical lights.

d) Luminaire placement and optics should mitigate glare and veiling reflections.

5.1.15 *Oral Surgery, Minor Procedure Room Design Parameters*

a) Average Maintained Illumination at Ambient - 2000 lux at 900 mm AFF

b) Average Maintained Illumination - Task / Focus
    i) Setup/Cleanup: 1000 lux at 900 mm. AFF
    ii) Recovery, General - 100 lux at 900 mm. AFF
    iii) Surgery Chair - 3000 lux at 900 mm. AFF on chair
    iv) Recovery Chair - 750 lux at 900 mm. AFF on chair

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 5000° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.15.1 *Design approach*

a) A combination of ambient, surgery and task illumination should be provided to reach desired illumination levels. Both horizontal and vertical illumination is important for a dentist's performance.

b) Luminaires should be visually comfortable with appropriate optics to minimize glare during examinations when the patient is in a reclining position.

c) Color rendering and temperature are particularly important.

5.1.15.2 *Controls*

a) All lighting shall be fully dimmable to provide flexibility during preparation, procedures and clean-up.

b) Coordinate location of room and medical equipment light control stations and provide station at door. Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

5.1.15.3 *Additional requirements*

a) Operating rooms require supplemental medical surgical and procedure lights. Hence lighting needs coordinated placement with such work and equipment layouts.

b) The room luminaires match the CCT and CRI of supplemental medical lights.

c) Luminaires shall be enclosed and sealed, IP65/UL listed for wet locations and have the ability to be wiped down with corrosive cleaners.

d) Luminaire placement and optics to mitigate glare and veiling reflections.

5.1.16 *Pharmacy Design Parameters*

a) Maintained Illumination at Ambient - 1000 lux at 900 mm AFF

b) Average Maintained Illumination - Task / Focus:

i)Compounding Areas: 1000-1500 lux at 900 mm AFF

ii)Storage - 300 lux at finished floor

iii)Storage Shelving - 500 lux at vertical face of shelving

iv)Receiving: 500 lux at 900 mm. AFF

c) Uniformity Ratio (max / min) at Ambient - 2:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

5.1.16.1 Design approach

a) Both horizontal and vertical illumination should be considered, especially in storage areas.

5.1.16.2 *Controls*

a) Multi-level dimming controls for LED luminaires.

b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.

5.1.16.3 *Additional requirement*

a) Luminaires shall be enclosed and sealed, IP65 / UL listed for wet locations and have the ability to be wiped down with corrosive cleaners and comply.

6 PATIENT CARE AREAS

6.1 Patient Rooms

When designing the lighting system for patient rooms, several factors should be considered:

a) *Task and ambient lighting* — The lighting design should provide a combination of task and ambient lighting to address the various activities and zones within the room. The patient zone requires adequate lighting for reading, personal tasks, and overall comfort. The caregiver zone should have ample task lighting for medical procedures and documentation. The family zone should provide a welcoming and comfortable environment for visitors.

b) *Flexibility and adjustability* — The lighting system should be flexible and adjustable to accommodate the changing needs and preferences of patients, caregivers, and family members. Dimming controls can allow patients to adjust the lighting levels according to their comfort, while caregivers can have control over task lighting for specific procedures. This flexibility also extends to the ability to adjust lighting levels for cleaning and maintenance purposes.

c) *Circadian rhythm-supportive lighting* — Recognizing the importance of circadian rhythms in patient well-being, lighting systems should support the natural sleep-wake cycle. Daylight should be maximized during the day, either through windows or artificial daylight simulation. At night, the lighting should be designed to provide a darker environment to promote better sleep. Night lighting should be provided to ensure safety and fall prevention, but with lower illuminance levels compared to daytime.

d) *Energy efficiency* — Energy efficient lighting solutions should be incorporated to minimize energy consumption and reduce environmental impact. This can be achieved through the use of LED lighting fixtures, occupancy sensors, and daylight harvesting systems to optimize energy usage.

e) *Maintenance and infection control* — The lighting fixtures should be designed for easy maintenance and cleaning. Consideration should be given to selecting fixtures that are easy to access, have sealed designs to prevent dust accumulation, and are resistant to cleaning agents. This helps ensure a clean and hygienic environment for patients.

f) *Compliance with regulations* — The lighting design should adhere to relevant regulations, codes, and standards, including those related to electrical safety, infection control, and patient well-being.

By considering task and ambient lighting, flexibility, circadian rhythm support, energy efficiency, maintenance and compliance with regulations, the lighting system in patient rooms can contribute to a comfortable, safe, and healing environment for patients, caregivers, and family members. Fig. 4 illustrates a comprehensive lighting strategy in healthcare settings, including focused exam lighting for caregivers, ambient lighting for occupants comfort, and accent lighting to enhance the environment. Fig. 5 depicts a single-patient floor plan delineating distinct zones including the patient zone, caregiver zone, and family zone, facilitating efficient and tailored healthcare delivery.

Fig. 4 Layered Lighting

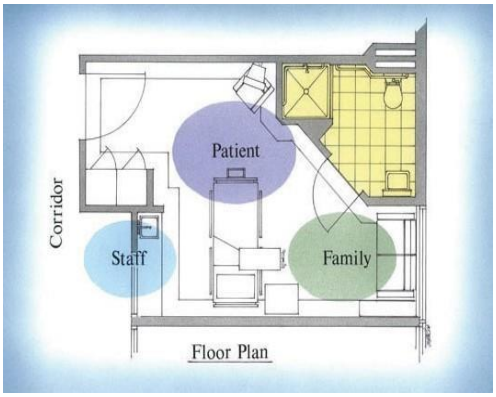

Fig. 5 Single Patient Floor Plan

The lighting requirements for patients vary based on their condition. Some patients may be more active, sitting up to watch television, use electronic devices, or read. In contrast, others who are more ill may spend extended periods lying down, with the ceiling as their primary visual focus. It's important to consider these differences in patient needs when designing lighting solutions for healthcare environments.

When designing lighting for multi-patient rooms, it's crucial to prioritize the privacy and comfort of each patient. The layout often features overlapping zones, and ceiling curtain tracks are used to create divisible areas, adding complexity to the lighting design. It's essential to ensure that night lighting, which illuminates the path to the restroom, remains unobstructed by curtains, whether they are open or closed. Given the limited ceiling space, a common approach is to use dimmable or multilevel fixtures to provide various levels of task illumination. Control devices should be strategically placed to ensure that wall-mounted devices in caregiver and family zones remain accessible when curtains are closed. Switches at entrance doors that control lights in patient zones should be properly labelled and operate in the same sequence for all multi-bed patient rooms to prevent inadvertent activation. Each zone has unique lighting needs, so it's important to offer flexible control options for each zone. Dimming and/or multi-level intensity control is recommended, with patients having control over at least the lighting in their zone from their bed, typically via a pillow speaker handset. Windows and views are important for patient well-being, so consideration should be given to window shade control. Night lighting for the safety of caregivers and patients moving to the toilet should also be a priority.

Emergency power requirements shall be considered with the examination lighting on the emergency critical branch and night lighting on the emergency life safety branch. The control for the examination lighting is typically red in color and located at the headwall, easily accessible and readily apparent for staff responding to codes.

6.2 General Considerations for Patient Rooms

When designing the lighting system, the specifier should consider the supine patient. It is important to prevent direct view of lamp sources and to minimize large areas of surface brightness that could become potential glare sources. The designer should also consider design solutions that evoke comforting and relaxing emotions. Luminaires should be placed so as to avoid veiling reflections on televisions and hand-held electronic devices. The presence of curtains in multi-patient rooms introduces a layer of complexity, necessitating meticulous attention to their positioning, whether open or closed in the lighting design, as illustrated in Fig. 6. Wall sconces bring a homely feel to patient room. The inclusion of natural daylight and views of nature further enhance the room's allure, as depicted in Fig. 7.

Fig. 6 Multi-Patient Room Curtain Complexity **Fig. 7 Wall sconces in Multi-Patient Room**

It is important to keep in mind that patients should be given control of as many environmental factors as possible. A patient’s anxiety is heightened when there is a sense of no longer being in control of the situation. Therefore, providing patients with the ability to control certain aspects of their environment is important.

6.3 Patient Zone – Ambient

Ambient light levels are typically controlled at the entrance of the patient zone but should also be controllable by the patient via a pillow speaker handset or bed controls. Architectural lighting control devices should be coordinated with these medical equipment control devices to provide

this functionality. Personal preferences for comfortable ambient light levels can vary greatly, utilizing dimming controls is recommended.

6.4 Patient Zone – Reading

The patient should have control via the pillow speaker and/or bed controls for achieving required reading illumination levels. Typical configurations for the bed are shown in Fig. 8. The designer should be careful to consider possible resultant shadows or reflected glare when the bed is elevated.

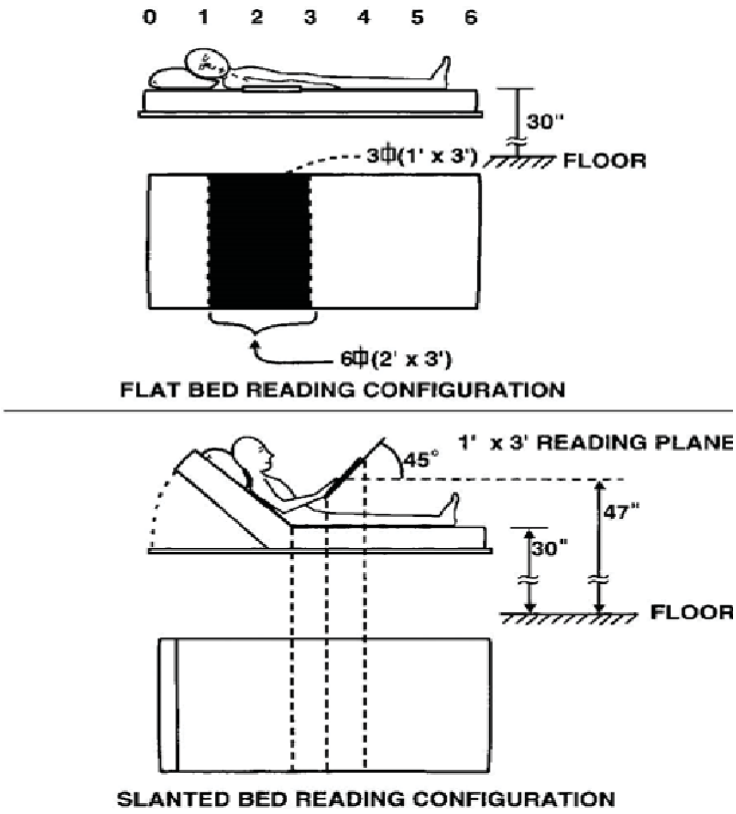

Fig. 8 Reading Configurations for a Flat Bed and Slanted Mattress

Fig. 9 Downlights in the Patient Room

The exam illumination is often provided by downlights and should be independently switched from the headwall so that it is easily accessible to the caregiver (see Fig. 9).

If 3-way switching is utilized, with a second switch located at the room entrance, this switch should be separate from any other switch located at the entrance, red in color, and properly labeled to avoid accidental switching while the patient is sleeping. Consider dimmable exam lighting for use by staff in the evening hours to check on the patient when the patient or family is sleeping.

6.5 Caregiver Zone

The caregiver zone lighting requires controllability by staff at the room entrance. Stepped switching or dimming strategies provide the flexibility to keep illumination low during evening hours.

6.6 Family Zone

The family zone should have independent control for visitors utilizing this zone. Family members often remain in the patient room reading or performing other tasks while the patient rests and require different light levels. It is important to provide adequate task illumination without providing vertical surface brightness that will be visible to the patient. Dimming is recommended.

6.7 Night Lighting

Night lighting is should be controlled by a photosensor so that lights are on whenever the room is dark, to maximize energy savings while aiding in fall prevention. Amber, red or warm-white correlated color temperature sources are recommended for nightlights.

6.8 Window Shades

Patient control (as well as control by family and staff) of window shading should be considered.

6.9 Safety Considerations

Any potential lamp breakage should be contained within the luminaire. Ceiling-mounted fixtures should be supported independent of suspended ceiling systems.

Wall-mounted luminaires should address the following concerns

a) Interior of fixture should not be accessible.

b) Decorative luminaires with glass may not be advisable due to breakage concerns.

c) Luminaire construction should minimize dust and debris accumulation.

d) Luminaire construction should be capable of withstanding routine surface wipe-down.

e) Bariatric lifts and the lighting must be coordinated with the placement of the lift rails as shown in Fig. 10. Ease of maintenance should be considered in luminaire selection, including the ability to stock drivers.

f) Luminaire finishes should be tested using prevalent healthcare disinfection solutions and methods.

g) Coves and fixture surfaces that collect dirt or debris should be avoided.

Fig. 10 Bariatric Lifts Share Ceiling Space with Overhead Lighting

A primary concern for healthcare facilities is the prevention of trips and falls which are most likely to occur at night as sleepy patients try to navigate to the toilet room in unfamiliar surroundings. The patient toilet and bathing room located within the patient room should be well illuminated for staff and patient needs (see Fig 11). Patients are often assisted by caregivers or family members in the toilet room. The selection and placement of luminaires should prevent shadows from curtains and caregivers that could interfere with the illumination of task areas. Lighting at the mirror should be designed to illuminate the patient's face without causing shadows on the face. Occupancy sensors may be used to turn lights on automatically when patients enter the room in order to ensure the safety and provide an indication to caregivers Monitoring patients at night that a patient is toileting. To ensure that proper illumination levels are achieved to prevent trips and falls, nightlights that are photo-sensor-controlled may also be used.

Fig. 11 Illumination in Bathroom Room Located within the Patient Room

Some pre-packaged shower enclosures come with ceiling panels and lighting, the designer should coordinate the lighting with the shower specification.

A separate switch should be used for the shower light. Occupancy sensors are not recommended for control of these lights as movement behind a shower curtain may not be detected.

Light fixture placement should be coordinated with the location of shower curtains and bariatric lift tracks that extend into toilet rooms as shown in Fig. 12.

Fig.12. Bathroom lighting.

The location of ceiling-mounted lights should be coordinated with bathroom exhaust-fan placement.

6.10 Nurse Station Design Parameters

Fig. 13 Illumination in Nurse Station

a) Average Maintained Illumination at Ambient:

i)General Day - 300 lux at finished floor

ii)General Night/Quiet - 100 lux at finished floor

iii)ICU Day - 500 lux at finished floor

iv)ICU Night/Quiet - 300 lx at finished floor

b) Average Maintained Illumination - Task / Focus:
i) Desk Surface - 500 lux (50 FC) at 915 mm AFF

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

6.10.1 *Design Approach*

The nurse station lighting will include a combination of ambient and task lighting strategies as shown in Fig. 13, to allow for wayfinding, charting, note taking, filing, and computer work. Illumination levels should be uniform throughout the nurse station. Decorative lights such as sconces and pendants may be used for visual interest.

6.10.2 *Controls*

a) Multi-level dimming controls for LED luminaires.

b) Desk lights shall be controlled with integral occupancy sensors or switches.

c) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

d) Automatic daylight response by photocontrols for ambient lighting.

e) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

6.11 Patient Rooms Corridor Design Parameters

Fig. 14 Illumination in Patient Rooms Corridor

a) Average Maintained Illumination at Ambient:
   i)Day - 200 lux at finished floor

   ii)Night/Quiet - 50 lux at finished floor

b) Uniformity Ratio (max / min):

   i)Ambient Day - 2:1

   ii)Ambient Night -3:1

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

6.11.1 *Design Approach*

a) Patient circulation lighting should be consistent throughout each facility as shown in Fig. 14.
b) Lighting in corridors should be coordinated with adjacent spaces for a cohesive appearance.
c) Vertical illumination should be considered with respect to signage and wayfinding.

d) Consider locations of decentralized nurse stations when placing luminaires.

6.11.2 *Control*

a) Automatic full or partial OFF or scheduled OFF with local manual control devices for all lighting.

b) Automatic daylight response by photocontrols for ambient lighting.

6.11.3 *Specific Requirements*

a) Mitigation of possible glare from highly polished floors is a must.

b) Luminaires should be easily serviceable from below without the need to open the ceiling plenum.

c) Wall-mounted luminaires should be limited to 120 mm in depth when located between 690 mm inches and 101.5 mm from the finished floor level of walks, halls, corridors, passageways or aisles.

6.12 *Medication Room Design Parameters*

a) Average Maintained Illumination at Ambient - 500 lux at 915 mm AFF

b) Average Maintained Illumination - Task / Focus:

i)Desk Surface - 750 lux at 915 mm AFF

ii)Storage - 300 lux at vertical face of shelving

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

6.12.1 *Design Approach*

a) A combination of general and task lighting should be utilized for medication room.

b) Vertical illumination needs to be considered on storage shelves when placing light luminaires.

6.12.2 *Controls*

a) Multi-level or dimming controls for LED luminaires.

b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.

d) Under-cabinet lights shall be controlled with integral occupancy sensors or switches.

6.13 *Patient Room Detailed Design Parameters*

a) Average Maintained Illumination at Ambient - 100 lux at finished floor

b) Average Maintained Illumination - Task / Focus:

c) Reading: 400 lux at head of bed

d) Hand Washing Sink: 500 lux at 915 mm AFF

e) Examination: 1000 lux at patient bed

f) Night Observation: 100 lux at patient bed

g) Night Light: 2 lux at finished floor, to toilet and corridor

h) Uniformity Ratio (max / min) at Ambient - 3:1

i) Color Rendering Index (CRI) for LED ≥ 80

16.13.1 *Design Approach*

A combination of general, task and exam lighting should be provided to reach desired illumination levels (a), (b), (c) as shown in Fig. 15, Fig. 16 and Fig. 17. Locations of patient bed, charting area and hand washing sink should be considered when placing luminaires.

16.13.2 *Specific Requirements*

a) Avoid using luminaires with surfaces that collect dust and debris.

b) In multi-patient rooms, night lights to toilet and corridor should not be blocked by curtains.

c) Control devices must be accessible when curtains are closed.

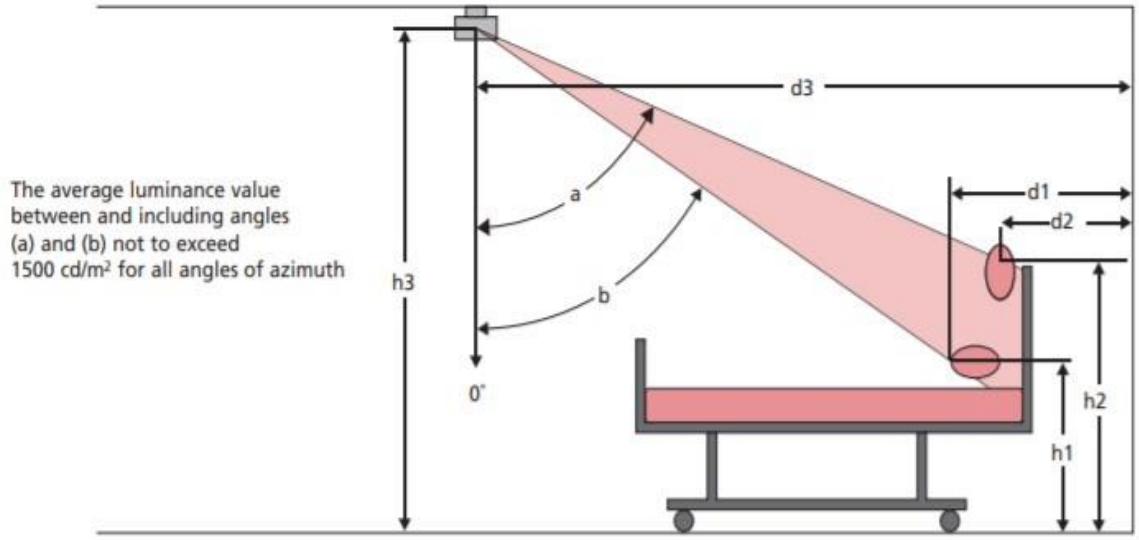

Fig. 15 Elevation Angles for Ceiling Mounted Luminaires

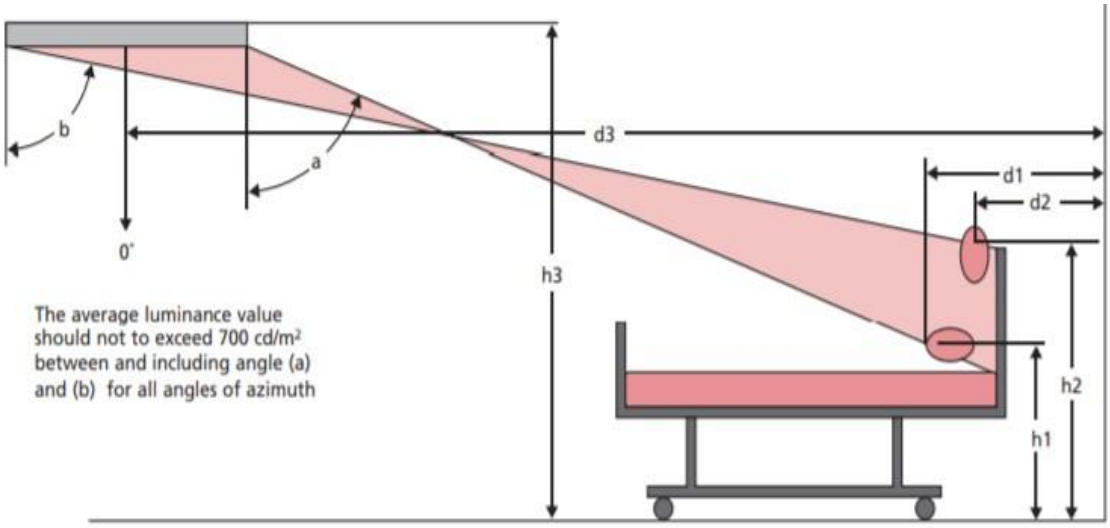

Fig. 16 Elevation Angles for Bed Head Rail Mounted Luminaires

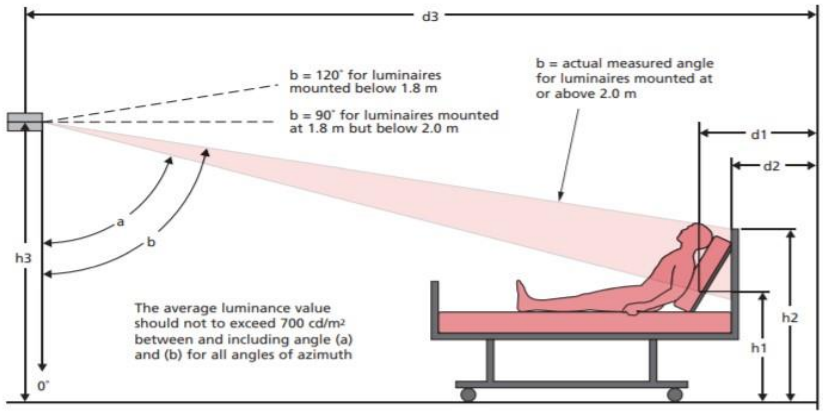

Fig. 17 Elevation Angles for Wall Mounted Luminaires

Patient room lighting should not cause glare to recumbent and ambulatory patients. Ceiling or wall mounted luminaires should be assessed for their average luminance value at elevation angles between and including angles (a) and (b) as shown in Fig. 15 ,16 and 17. Ceiling mounted, surface luminaires should not exceed 1500 cd/m2 for all angles of azimuth. For all ceiling recessed or semi-recessed luminaires the value should be reduced to 1000 cd/m2. Wall-mounted luminaires should be assessed to ensure that their average luminance value does not exceed 700 cd/m² for all angles of azimuth, including angles between them.

a) Angles a and b as defined in Fig. 17

b) h1 = minimum height of the mattress surface plus 200 mm

c) h2 = maximum height of the mattress surface plus 600 mm

d) h3 = height above floor level to the center of the luminaire

e) d1 = distance from the wall to the front edge of the pillow

f) d2 = distance from the wall to front face of bed head

g) d3 = distance from the wall to the luminaire center.

The average luminance value of 1500 cd/m2 (1000 cd/m2 for recessed or semi-recessed luminaires) is defined as the luminous intensity measured at each 5˚ angle between and including angles (a) and (b) divided by the sum of all the orthogonally projected luminous areas at each of the elevation angles. This average applies at all angles of azimuth. The average value of 700 cd/m2 for wall luminaires should not be exceeded anywhere between and including angles (a) and (b) for all angles of azimuth. The designer should use the measurement values relating to the actual or specific areas in question. However, in the absence of specific dimensional data for h1, h2, h3, d1, d2 and d3 the following values shall apply:

a) h1 = 850 mm

b) h2 = 1450 mm

c) h3 = 2.7 m ceiling mounted, 2.0 m rail mounted, 1.8 m wall mounted

d) d1 = 900 mm

e) d2 = 450 mm

f) d3 = 4.0 m ceiling mounted, 5.0 m rail mounted, 8.0 m wall mounted.

6.13.4 *Design Approach*

a) A combination of general, task, and exam lighting should be provided to reach desired illumination levels. Luminaires should be provided with sufficient shielding to minimize glare during examinations and when the patient bed is reclined.

b) Locations of patient bed, charting area, and hand washing sink should be considered when placing luminaires.

16.13.5 *Controls*

a) Multi-level switching shall be used for tasks including general, reading, night observation and exam lights.

b) General and reading lights shall be controlled with the patient pillow switch.

c) Exam light shall be controlled with a red switch at the patient headwall.

d) Light at hand washing sink shall be controlled with a switch above the sink.

e) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

f) Automatic daylight response by photocontrols for general and night lighting.

6.13.6 *Specific Requirement*

a) Avoid using luminaires with surfaces that collect dust and debris.

b) In isolation rooms, luminaires shall be specified as enclosed and sealed, IP65/ UL listed for wet locations and have the ability to be wiped down with corrosive cleaners.

6.14 Patient Room Intensive Care Design Parameters

a) Average Maintained Illumination at Ambient - 100 lux at finished floor
b) Average Maintained Illumination - Task / Focus:

c) Hand Washing Sink - 500 lux at 915 mm AFF

d) Examination: 1000 lux at patient bed

e) Night Observation - 100 lux at patient bed

f) Night Light: 2 lux at finished floor, to toilet and corridor

g) Uniformity Ratio (max / min) at Ambient - 3:1

h) Correlated Color Temperature (CCT) for LED - 3500° K
i) Color Rendering Index (CRI) for LED ≥ 80

6.14.1 *Design Approach*

a) A combination of general task and exam lighting should be provided to reach desired illumination levels. Luminaires should be provided with sufficient shielding to minimize glare during examinations and when the patient bed is reclined.

b) Locations of patient bed, charting area and hand washing sink should be considered when placing luminaires.

6.14.2 *Control Approach*

a) Multi-level switching shall be utilized for general and exam lighting.

b) Recessed fixtures should be controlled with a dimming switch.

c) Exam light shall be controlled with a red switch at the patient headwall.

d) Automatic full OFF or scheduled OFF with local manual control devices for all lighting. Automatic daylight response by photo controls for general and night lighting.

6.14.3 *Patient Toilet/Shower Design Parameters*

a) Average Maintained Illumination at Ambient - 300 lux at 455 mm. AFF

b) Average Maintained Illumination - Task / Focus:

i)Shower - 200 lux at finished floor

ii)Night Light - 10 lux at finished floor

c) Uniformity Ratio (max / min): N/A
d) Correlated Color Temperature (CCT) for LED - 3500° K
e) Color Rendering Index (CRI) for LED ≥ 80

6.14.4 *Specific Requirement*

a) Bariatric care rooms must coordinate luminaire placement with ceiling track and ceiling track supports.

b) Lighting in the toilet rooms should be located to coordinate with plumbing fixtures, vanities, and wall-mounted equipment.

6.15 Multi-Purpose Activity Room Design Parameters

a) Average Maintained Illumination at Ambient - 50 lux at finished floor

b) Average Maintained Illumination - Task / Focus:

i)Games: 200 lux at 75mm AFF

ii)Crafts: 500 lux at 75 mm AFF

iii)Kitchenette: 500 lux at 900 mm AFF on counter

c) Uniformity Ratio (max / min) at Ambient - 3:1

d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

6.15.1 *Design Approach*

The multi-purpose activity rooms should include a combination of lighting strategies to perform a variety of tasks. Both horizontal and vertical illumination must be considered for multipurpose rooms.

6.15.2 *Controls*

a) Multi-level dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.
c) Automatic daylight response by photocontrols for ambient lighting.

6.16 ***Dressing Room Design Parameters***

a) Average Maintained Illumination at Ambient - 300 lux at 765 mm. AFF
b) Uniformity Ratio (max / min) at Ambient - 3:1
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 90

6.16.1 *Design Approach*

Consider both horizontal and vertical illumination for dressing rooms.

6.16.2 *Controls*

a) Multi-level dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control device for all lighting.
c) Automatic daylight response by photocontrols for ambient lighting.

7 HOSPITAL LOBBY

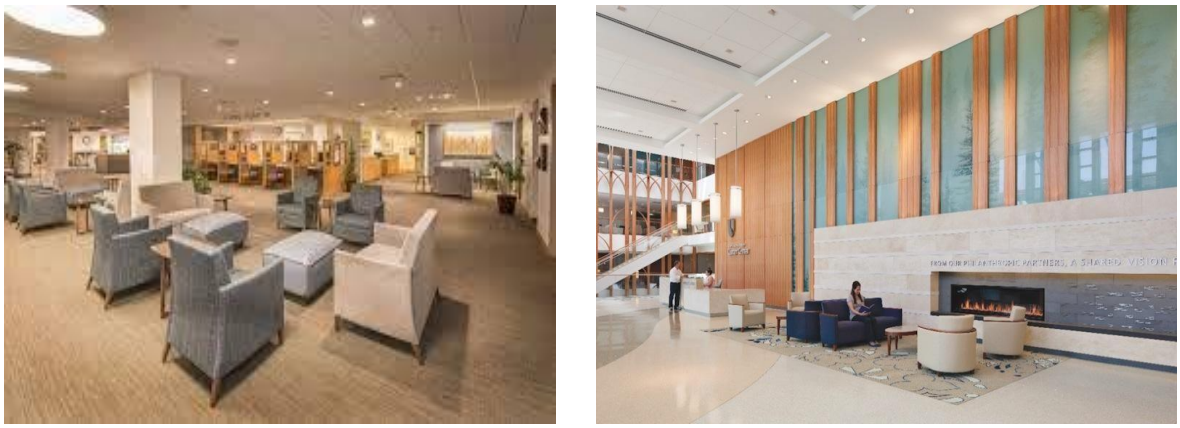

Fig. 18 Illumination in Hospital Lobby

7.1 Main Lobby Design Parameters

a) Average Maintained Illumination at Ambient:

   i)General Day: 400 lux at finished floor

   ii)General Night: 200 lux at finished floor

b) Uniformity Ratio (max / min) at Ambient - 5:1
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80

7.1.1 *Design Approach*

a) Lighting in the main lobby should be aesthetically pleasing, and enhance the architectural features of the space as shown in Fig.18

b) Lighting should reinforce wayfinding for patients and visitors through the use of brightness and contrast, with emphasis placed on signage and reception desk.

c) Decorative luminaires, such as pendants and sconces, may be utilized for visual interest.

7.1.2 *Controls*

a) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

b) Daylight response by photocontrols for ambient lighting.

7.1.3 *Specific Requirement*

a) Wall-mounted sconces must be mounted and should be regulations compliant.

b) Luminaire maintenance requirements should be considered when locating

c) Luminaires in high ceilings.

7.2 Elevator Lobby Design Parameters

a) Average Maintained Illumination at Ambient:

   i)Day - 200 lux at finished floor

   ii)Night - 100 lux at finished floor

b) Uniformity Ratio (max / min) at Ambient - 4:1

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

7.2.1 *Design Approach*

a) The elevator lobby should have a higher illumination level than surrounding corridors to support wayfinding for patients and visitors.

b) Decorative luminaires may be added for visual interest.

7.2.3 *Control*

a) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

b) Automatic daylight response by photocontrols for ambient lighting.

7.3 Waiting Area Design Parameters

a) Average Maintained Illumination at Ambient:

   i)Day: 200 lux at finished floor

   ii) Night: 100 lux at finished floor

b) Average Maintained Illumination - Task / Focus:
   i)Sitting Area: 600 lux (60 FC) at 765 mm AFF

c) Uniformity Ratio (max / min) at Ambient - 5:1

d) Correlated Color Temperature (CCT) for LED: 3500° K

7.3.1 *Design Approach*

a) Lighting in the waiting area should have a combination of general and task lighting.

b) Consider vertical illumination for facial recognition and conversation.

c) Decorative luminaires such as sconces or pendants may be added for visual interest.

7.3.2 *Control*

a) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

b) Automatic daylight response by photocontrols for ambient lighting.

7.3.3 *Specific Requirement*

a) Sconces must be compliant with regulations in healthcare facilities

7.4 Primary Corridors - Parameters

a) Average Maintained Illumination at Ambient - 100-150 lux at finished floor

b) Uniformity Ratio (max / min) at Ambient - 4:1 general

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

7.4.1 *Design Approach*

a) Primary circulation lighting should be consistent throughout each facility.

b) Lighting in corridors should be coordinated with adjacent spaces for a cohesive appearance.

c) Vertical illumination should be considered, especially with regard to signage and artwork displays. Decorative sconces may be used to add visual interest.

7.4.2 *Control*

a) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

7.4.3 *Specific Requirement*

a) Sconces must be compliant with regulations in healthcare facilities

7.5 Secondary Corridors Design Parameters

a) Average Maintained Illumination at Ambient - 50-100 lux at finished floor
b) Uniformity Ratio (max / min) at Ambient - 4:1
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80

7.5.1 *Design Approach*

a) Secondary circulation lighting should be consistent throughout each facility.
b) Lighting in corridors should be coordinated with adjacent spaces for a cohesive appearance.
c) Vertical illumination should be considered with respect to signage and wayfinding.

7.5.2 *Control*

a) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

7.5.3 *Specific Requirements*

a) Sconces must be compliant Healthcare regulations.

7.6 Canteen Design Parameters

a) Average Maintained Illumination at Ambient:

   i) Dining: 150 lux at 915 mm AFF

   ii)Food Storage: 100 lux at 765 mm AFF

   iii)Equipment Storage: 200 lux at 765 mm

b) Average Maintained Illumination - Task / Focus:
   i)Serving Line: 500 lux at food handling surface

   ii)Grab and Go: 200 lux at food display

   iii)Kitchen: 200 lux at 765 mm AFF

   iv)Food Preparation: 500 lux at 915 mm on countertop

c) Uniformity Ratio (max / min) at Ambient - 3:1 in dining areas
   i)Food Displays: 2:1

d) Correlated Color Temperature (CCT) for LED - 3500° K
e) Color Rendering Index (CRI) for LED ≥ 80

7.6.1 *Design Approach*

a) Horizontal and vertical illumination should be considered when illuminating food displays and food storage.

b) Decorative sconces or pendants may be used to add visual interest. Heat lamps may be required to keep food warm.

7.6.1 *Controls*

a) Multi-level dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.
c) Automatic daylight response by photocontrols for ambient lighting.

7.6.2 *Specific Requirement*

a) Coordinate heat lamps with food serving and display areas.
b) Sconces must be compliant with healthcare regulations /architectural requirements.
c) To avoid food contamination from violent lamp failure, lamps must be fully enclosed in luminaire.

7.7 Reception Design Parameters

a) Average Maintained Illumination at Ambient - 300 lux at 765 mm AFF
b) Uniformity Ratio (max / min) at Ambient - 5:1
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80

7.7.1 *Design Approach*

a) Vertical illumination should be considered to illuminate the reception desk or wall behind the reception desk.

b) Decorative sconces or pendants may be used to add visual interest.

7.7.1 *Control*

a) Multi-level dimming controls for LED luminaires.

b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.

c) Automatic daylight response by photocontrols for ambient lighting.

7.7.2 *Specific Requirement*

a) If decorative pendants are used, ensure the mounting height does not interfere with the line-of sight for receptionist.
b) Sconces if used must be compliant with healthcare regulations /architectural requirements.

7.8 SUPPORT AREAS

Below Fig. 19 shows the support areas.

Fig. 19 Support Areas

8.1 Storage Design Parameters

a) Average Maintained Illumination at Ambient:

   i)Bulk Storage - 100 lux at finished floor

   ii)Clean/Sterile Storage - 200 lux at finished floor

   iii)Filing - 300 lux at 765 mm AFF

b) Uniformity Ratio (max / min) -N/A
c) Color Rendering Index (CRI) for LED ≥ 80

8.1.1 *Design Approach*

a) Consider vertical illumination on shelving in storage rooms.

8.1.2 *Control*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control device for all lighting.

b) Automatic daylight response by photocontrols for ambient lighting.

8.1.3 *Specific Requirement*

a) If using industrial fixtures, provide with lamp shield or guard.
b) In gas cylinder storage rooms, provide luminaires with hazard rating matching room rating.

8.2 Housekeeping Design Parameters

a) Average Maintained Illumination of Ambient - 100 lux at finished floor
b) Uniformity Ratio (max / min) - N/A
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80

8.2.1 *Design Approach*

a) Consider vertical illumination on shelves.

8.2.3 *Control*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

8.3 Soiled Utility Room Design Parameters

a) Average Maintained Illumination of Ambient - 200 lux at finished floor

b) Uniformity Ratio (max / min) of Ambient - 3:1

c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

8.3.1 *Design Approach*

a) Consider vertical illumination on shelves.

8.3.2 *Control*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

8.4 Clean Utility Room Design Parameters

a) Average Maintained Illumination at Ambient - 200 lux at finished floor
b) Uniformity Ratio (max / min) at Ambient - 3:1

c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80

8.4.1 *Design Approach*

a) Consider vertical illumination on shelves.

7.9 Maintenance/Repair Shops Design Parameters

a) Average Maintained Illumination at Ambient - 300 lux at 915 mm AFF
b) Average Maintained Illumination - Task Focus:
    i) Benches: 1000 lux at 915 mm on benches
c) Uniformity Ratio (max / min) at Ambient - 3:1
d) Correlated Color Temperature (CCT) for LED - 3500° K
e) Color Rendering Index (CRI) for LED ≥ 80

8.5.1 *Design Approach*

a) Consider vertical illumination and body shadows at machines and equipment.

8.4.2 *Controls*

a) Multi-level dimming controls for LED luminaires.
b) Automatic full OFF or scheduled OFF with local manual control devices for all lighting.
c) Automatic daylight response by photocontrols for ambient lighting.
d) Under-cabinet lights shall be controlled with integral switch.

8.4.3 *Specific Requirement*

a) Provide all fixtures with lamp shield or guard.

9 STERILE PROCESSING AND DISTRIBUTION (SPD) CLEAN SIDE DESIGN PARAMETERS

a) Average Maintained Illumination at Ambient:
    i)Clean Receiving - 300 lux at 765 mm AFF
    ii)Ante Room - 300 lux at finished floor
b) Average Maintained Illumination - Task Focus:
    i)Autoclave - 500 lux at 765 mm AFF
c) Manual Equipment Wash: 500 lux
d) Uniformity Ratio (max / min) at Ambient - 3:1
e) Correlated Color Temperature (CCT) for LED - 3500° K
f) Color Rendering Index (CRI) for LED ≥ 80

9.1 Design Approach

Light fixtures in the SPD areas shall be sealed and casketed to prevent steam from entering, and have a minimum rating of IP65.

9.1.1 *Controls*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

9.2 Sterile Processing and Distribution Equipment Preparation Design Parameters

a) Average Maintained Illumination at Ambient

   i)Preparation and Assembly - 300 lx at 765 mm AFF.

   ii)SPD Storage - 300 lux at finished floor

b) Average Maintained Illumination - Task Focus:
   i)Pack Inspection - 500 lux at 765 mm AFF

c) Uniformity Ratio (max / min) at Ambient - 3:1
d) Correlated Color Temperature (CCT) for LED - 3500° K

e) Color Rendering Index (CRI) for LED ≥ 80

9.2.1 *Design Approach*

a) Light fixtures in the SPD areas shall be sealed and gasketed to prevent steam from entering, and have a minimum rating of IP65.

9.2.2 *Control Approach*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control devices for all lighting

b) Automatic daylight response by photocontrols for ambient lighting.

9.3 **Sterile Processing and Distribution (SPD) -** Detergent and Water Areas

a) Average Maintained Illumination at Ambient - 300 lux at 765 mm AFF

b) Uniformity Ratio (max / min) at Ambient - 3:1
c) Correlated Color Temperature (CCT) for LED - 3500° K

d) Color Rendering Index (CRI) for LED ≥ 80

9.3.1 *Design Approach*

a) Light fixtures in the SPD areas shall be sealed and gasketed to prevent steam from entering, and have a minimum rating of IP65.

9.3.2 *Control*

a) Manual ON with automatic full OFF or scheduled OFF with local manual control devices for all lighting.
b) Automatic daylight response by photocontrols for ambient lighting.

10 ELECTRICAL AND MECHANICAL ROOMS DESIGN PARAMETERS

a) Average Maintained Illumination at Ambient:
   i)Electrical: 100 lux at 915 mm AFF

   ii)Switchgear: 500 lux

   iii)Mechanical: 200 lux at 915 mm AFF

   iv)IT/Computer Service: 500 lux

   v)Critical branch of the supply power for 50% of electrical rooms.

   vi)Critical branch of the supply power for 100% of IT rooms.

   vii) Battery powered emergency lighting at main electrical and generator rooms
b) Uniformity Ratio (max / min) at Ambient - 3:1
c) Correlated Color Temperature (CCT) for LED - 3500° K
d) Color Rendering Index (CRI) for LED ≥ 80.

10.1 Design Approach

a) Lighting should provide vertical and horizontal Illumination and illuminate below and above.

11 ELECTRO-MAGNETIC COMPATIBILITY (EMC)

Many electrical equipment used in hospitals can generate interference either through radiation or transients in the mains voltage supply. Fluorescent luminaires in particular, can contribute to radio interference. To mitigate this interference, suppressors can be installed in the ballasts of the luminaires to reduce the emission of electromagnetic interference (EMI).

When using high-frequency electronic control gear within the patient environment, careful consideration should be given to electromagnetic compatibility (EMC) emissions and immunity. This means that the equipment should be designed and tested to minimize both its emissions of electromagnetic radiation and its susceptibility to external interference.

12 UV-C FOR DISINFECTION IN HEALTHCARE FACILITIES

Ultraviolet (UV) light in the germicidal range (100-280 nanometers) has the ability to kill or disable bacteria and viruses, including the virus that causes COVID-19. This range of UV light is known for its disinfection properties.

When UV light enters a cell, it disrupts the structure of nucleic acids and proteins, preventing the organism from functioning properly or reproducing. This makes UV light an effective tool for disinfection as it can inactivate microorganisms on surfaces, in the air and in water.

The use of UV light for disinfection purposes should follow recommended guidelines and safety precautions. Exposure to UV light can be harmful to human skin and eyes, so it is essential to use UV disinfection technologies in controlled settings and ensure that appropriate safety measures are in place.

Exposure to UVC light can cause a sunburn-like reaction on the skin, and prolonged or direct exposure to UVC light can be hazardous. Therefore, it is essential to follow safety guidelines and use appropriate control devices to minimize the risk of exposure to UVC light.

Proper training and understanding of the equipment are essential to ensure safe and effective use of UVC devices. This includes using appropriate personal protective equipment (PPE), controlling exposure time and distance and implementing safety protocols to protect both patients and healthcare workers.

The use of UVC devices should be carried out by trained professionals who understand the potential risks and know how to use them safely. Adhering to manufacturer instructions and industry guidelines is crucial to ensure the safe and effective use of UVC disinfection system (see Fig. 20).

Fig. 20 Illumination in UVC Disinfection System

Some devices also produce ozone as part of their cycle, others produce light and heat like an arc welder, others move during their cycles. Hence, general machine-human safety needs to be considered with all disinfection devices and these considerations should be addressed in the operations manual, in the user training, and appropriate safety compliance.

13 LIGHTING FOR CLINICAL OBSERVATION OF CYANOSIS

Clinical observation plays a crucial role in medical diagnosis, and accurate detection of cyanosis is essential for identifying underlying medical conditions. The quality of light in healthcare settings is indeed important for medical staff to accurately observe skin tones and identify cyanosis. The Cyanosis Observation Index (COI) has been established as a parameter to determine the suitability of a light source for detecting cyanosis.

According to the recommended guidelines, light sources with a COI of 3.3 or less should be used for visual detection of cyanosis. Additionally, the correlated color temperature (CCT) of the light source should be between 3300K and 5300K and the color rendering index (CRI) should be equal to or greater

than 80. These specifications ensure that the light source provides appropriate visual conditions for detecting cyanosis accurately.

By using light sources with a low COI, appropriate CCT and sufficient CRI, medical personnel can optimize their ability to detect cyanosis and identify potential underlying health issues. It highlights the importance of selecting the right lighting solutions in healthcare facilities to support accurate clinical observations and improve patient care.

14 ROADWAYS DESIGN PARAMETERS - EXTERNAL LIGHTING GUIDELINES

a) Average Maintained Illumination:

   i)Pedestrian Conflict Area - 8-12 lux

   ii)No Pedestrian Conflict Area - 6-9 lux

b) Uniformity Ratio (ave. / min):

   i)Primary Roadways - 4:1

   ii)Secondary Roadways - 6:1

c) Correlated Color Temperature (CCT) for LED - 4000° K

d) Color Rendering Index (CRI) for LED ≥ 85

14.1 Design Approach

a) Lighting should enhance nighttime visibility to promote safety and security for pedestrians and vehicles.

b) Provide increase illumination at signage, pedestrian crosswalks, and bus stops.

c) Consider photometric distribution types when selecting and spacing to minimize pole locations.

d) Luminaires should be mounted on one side unless uniformity limits are exceeded. When mounted on both sides, the poles should be staggered.

14.1.1 *Control*

a) Photocontrols for all luminaires.

b) Automatic control zones with time schedule for all exterior lighting circuits. circuits.

14.1.2 *Specific Requirements*

a) Luminaires shall be enclosed and sealed in weatherproof housing with IP 66 Rating / UL listing for wet locations.

b) Comply with Dark Sky recommendations.

c) Roadway surface luminance impacts night time visibility and should be considered.

d) Coordinate pole and luminaire with exterior building and landscape color palette.

e) Coordinate pole locations with civil and landscape features, signage, pedestrian crosswalks, underpasses, overpasses and bus stops

f) Coordinate pole base height to reduce pole damage. Consider elevated bases when located in vehicular ways.

g) Coordinate pole-mounted security cameras and devices, banners, and signs with structural engineer.

h) Provide house side shields at property lines to mitigate light trespass.

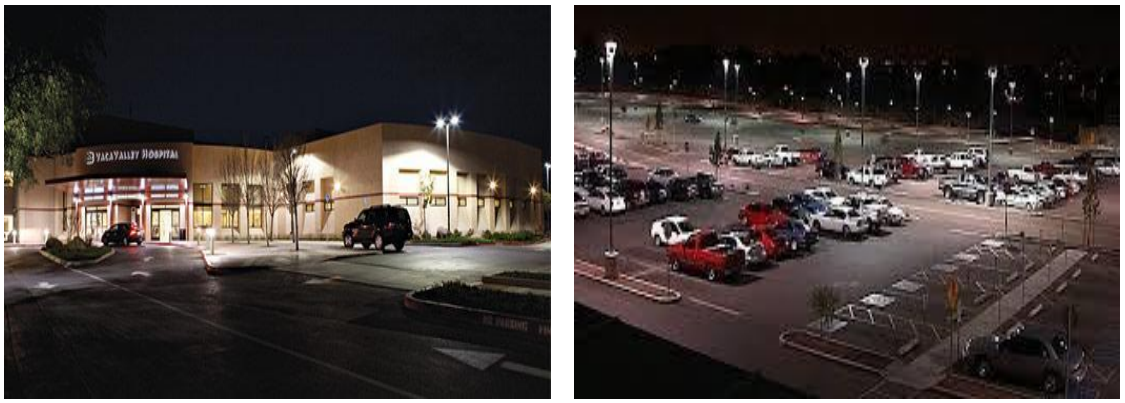

Fig. 21 Illumination in Open Parking Areas

14.2 Open Parking Areas Design Parameters

a) Average Maintained Illumination:

   i)Asphalt Surfaces: 5 lux minimum point

   ii)Concrete Surfaces: 10 lux minimum point

b) Uniformity Ratio (avg / min): 4:1

c) Correlated Color Temperature (CCT) for LED - 4000° K

d) Color Rendering Index (CRI) for LED ≥ 85

14.2.1 *Design Approach*

a) Lighting should enhance nighttime visibility to promote safety and security for pedestrians and vehicles as shown in Fig. 21. Higher pole heights will reduce glare and permit wider spacing.

b) Special consideration should be taken to provide increase illumination at signage, Pedestrian crosswalks, and bus stops.

14.2.2 *Control*

a) Photocontrols for all luminaires.

b) Automatic control zones with time schedule for all exterior lighting circuits.

14.2.3 *Specific Requirements to be Considered*

a) Luminaires shall be enclosed and sealed in weatherproof housing with suitable IP 65 Rating / UL listing for wet locations.

b) Comply with Dark Sky recommendations.

c) Coordinate pole and luminaire with exterior building and landscape color palette.

d) Coordinate pole locations with civil and landscape features, signage, pedestrian, crosswalks, underpasses, overpasses, and bus stops.

e) Coordinate pole base height to reduce pole damage. Consider elevated bases when located in parking areas.

f) Coordinate pole-mounted security cameras and devices, banners, and signs with structural engineer.

g) Provide house side shields at property lines to mitigate light trespass.

14.2.4 *Walkways Design Parameters*

a) Average Maintained Illumination:

i)Adjacent to Roadside: 10 lux

b) Remote from Roadway - 5 lux

c) Uniformity Ratio (ave / min) - 4:1

d) Correlated Color Temperature (CCT) for LED - 4000° K.

e) Color Rendering Index (CRI) for LED ≥ 85

14.3 Porticos / Entry Areas Design Parameters

a) Average Maintained Illumination:

i)Emergency/Ambulance: 500 lux

ii)Main: 50 lux

b) Uniformity Ratio (max /avg): 4:1

c) Correlated Color Temperature (CCT) for LED - 4000° K

Fig. 22 Illumination in Entry Areas

14.3.1 *Design Approach*

a) Lighting at building entrances shall include a combination of approaches to enhance nighttime visibility and promote safety and security as shown in Fig. 22.

b) Transitions should be highlighted to adjust for visual adaption throughout the day.

c) Vertical illumination and surface brightness should be considered to create a lit destination.

d) Decorative wall luminaires should be considered to provide visual interest and create a visual cue to mark the building entrance from a distance at night.

e) Color rendering and temperature are particularly important at the emergency/ambulance entrance where patient assessment can occur.

14.4Landscape Design Parameters

a) Average Maintained Illumination:

iTrees, Shrubbery - 30 lux

ii)Decorative Structures - 50 lux

iii)Focal Point - 50 lux

iv)Water Features - 30 lux

b) Color Temperature (CCT) for LED - 4000 degrees K with CRI 80 or above

.

14.4.1 *Design Approach*

a) Landscape lighting should be limited to entries, courtyards and meditation gardens, as well as the highlighting of building or landscape features (i.e., trees, plant life, artwork, water features, and hardscape).

b) Glare and direct light source view should be minimized by luminaire placement and aiming.

c) Color rendering and temperature should be evaluated with the features being illuminated.

14.4.2 *Specific Requirements*

a) Luminaires shall be enclosed and sealed in weatherproof housing with IP 68 Rating / UL listing for wet locations.

14.5 Bulding Perimeter - Design Parameters

a) Average Maintained Illumination

i)Non-Public Building Entries - 30 lux

ii)Walkways Adjacent to Perimeter - 5 lux

iii)Loading Dock Platforms - 30 lux

b) Uniformity Ratio (max / avg.) -4:1

c) Correlated Color Temperature (CCT) for LED - 4000° K

d) Color Rendering Index (CRI) for LED ≥ 85

14.5.1 *Control Approach*

a) Photo controls for all luminaires.

b) Automatic control zones with time schedule for all exterior lighting circuits.

14.5.2 *Specific Requirements*

a) Luminaires shall be enclosed and sealed in weatherproof housing with IP 66 Rating/ UL listing for wet locations.

b) Comply with Dark Sky recommendations.

c) Coordinate luminaire with exterior building color palette.

d) Coordinate luminaire layout with building elevations.

14.6 Parking Structures Design Parameters

a) Average Maintained Illumination:

   i) Basic: 50 lux with a minimum point of 10 lux

   ii) Ramps Day: 100 lux with a minimum point of 20 lux

   iii) Ramps Night: 50 lux with a minimum point of 10 lux

   iv) Entrance Areas Day: 2500 lux with a minimum point of 500 lux

   v) Entrance Areas Night: 50 lux with a minimum point of 10 lux

   vi) Stairways: 20 lux

   vii) Top Level Open to Sky: 25 lx with a minimum point of 5 lux

b) Uniformity Ratio (max / min) - 10:1

c) Correlated Color Temperature (CCT):

i) LED: 4000° K

ii) Color Rendering Index (CRI) for LED ≥ 85

iii) Provide brightness at ceiling to improve contrast between deck and side wall openings.

iv) Glare and direct light source view should be minimized by luminaire selection and placement.

v) Transitions should be highlighted to adjust for visual adaption throughout the day.

vi) Signage, pedestrian walkways, and elevator lobbies should be illuminated to create lit destinations.

The top deck should be treated as an exterior parking area using pole-mounted luminaires mounted on the perimeter and ramps.

14.6.1 *Control Approach*

a) Photo controls for all luminaires.

b) Automatic control zones with time schedule for all exterior lighting circuits.

c) Automatically reduce light by stepped switching or dimming when no activity is detected by local sensors.

14.6.2 *Specific Requirement*

a) Luminaires shall be enclosed and sealed in weatherproof housing with suitable IP Rating/ UL listing for wet locations.

b) Consider luminaire options to discourage nesting by birds.

Draft for comments only **Doc: ETD49 (25578) P**

May 2024

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

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Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 5 Hospitality Lighting

[First Revision of SP 72 (Part 5/Section 5)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49

Last Date for Comments: 06-June-2024

FOREWORD

Visual composition and aesthetics are inevitable proponents of crafting lighting into built space. Lighting design for hospitality and entertainment spaces, such as, Hotels, restaurants, casino, Spa, Fitness centre, exhibition halls, Ballroom or Function spaces, Movie Theatres, Theatre and Performance centre, the visual experience is a vital part of design process.

The dramatic play with lighting shapes the spatial ambience in such a way to provide the users a specially crafted unique experience. This building type is one of the first amongst others that began using professional lighting designers as there was a strong need to creatively shape extraordinary ambience through lighting with thorough understanding of both lighting science and technology and strong knowledge of interior design, landscape design and architectural built form and conceptualization. Lighting should be subtly detailed into the built structure.

The design process should set specific aesthetic and compositional goals that pertains to the interior design scheme, i.e., colours, materials, finishes, furniture and functional goal of every space. Lighting for this context requires visual contrast in lobbies, Restaurants, Spa and other spaces that has vertical illuminance for Art. This document provides guideline for best lighting application in hospitality and

entertainment, utilising best light sources with effective controls to provide a suitable standard of illumination and a pleasant ambience for residents.

1 SCOPE

This section of the code covers the principals and practices governing good lighting of hotels. Lighting applications with bright light source along with effective control provides appropriate illumination and a pleasant ambience for users.

2 NORMATIVE REFERENCE

Following International guides, handbooks and standards referred in this part and section are necessary adjunct to this standard:

1. SLL Lighting hand book
2. IESNA The Lighting-Handbook 10th Edition

3 FACTORS AFFECTING LIGHTING DESIGN

3.1 User / Occupants Needs

Visitors of all ages utilize these venues, often making them their temporary living spaces. It's crucial to assess each space based on the activities it hosts to tailor lighting accordingly. For instance, areas like ballrooms are versatile, accommodating various events and layouts. Thus, lighting design should be flexible to suit different settings and activities, ensuring seamless transitions. Moreover, lighting plays a vital role in aiding wayfinding and creating a comfortable, secure environment for users.

3.2 Interior Built Structure

Type of lighting fixtures to be installed is determined by the nature of structure whether it is true ceiling or false ceiling. It will also depend on the building material whether it is mounted on POP or raw concrete or wood. LED fixtures with remote driver needs to be integrated or placed in a ventilated location. The placement of the drivers needs to be coordinated with interior designer and electrician.

Electrical circuit design needs to be coordinated with lighting schematic drawings and to be strategically timed to provide information to project team during various stages of construction for better integration. It should be worked out in such a way that the lighting is seamlessly concealed where it is meant to be, and placement does not hinder light output.

3.3 Exterior

There are two parts to exterior scheme:

a) *Landscape* — Landscape drawings to be studied extensively to understand the type of landscape contour, shrubs, trees and ground cover. The Softscape planting specification and hardscape material specification provides an understanding of how lighting concept can be conceptualised as per form of landscape elements. The Landscape sections provide information on the levels, building materials, type of light fixture mounting possibilities.

Selection of fixtures and detailing needs to reflect the conceptual ambience with layers, patterns, highlights, textures and intensity, with shadows also a part of scheme along with light, allowing for right proportion of highlights and pause. Low glare fixtures ensure that the end light quality is better and does not affect the users. Fixtures also need to be aimed only at their end task thereby reducing the light pollution. Lighting at water features, swimming pool and pool deck to be planned to accommodate both lights for functional and aesthetic purpose. Light fixture provisions such as wiring and backboxes to be planned very early during construction phase before waterproofing.

b) *Building Façade* — The building façade for the hospitality sector is visual brand identity for the owner. Hence, façade lighting plays a major role in their brand marketing. The lighting concept has to be worked during the early stages of construction so that the electrical wiring can be planned, and provisions can be made and better concealed or integrated at this stage. Low glare fixtures ensure that the end light quality is better and does not affect the users. Fixtures also need to be aimed only at their end task thereby reducing the light pollution.

4 QUALITY OF LIGHT

The process of lighting design is to evaluate quality vs quantity of light in the right proportion. The design strategies where each of spatial design element is thought through and corresponding lighting technique is applied to each spatial element. There are several techniques as how light can be directed in a space and how each element is layered to form a visual scheme. Generic downlighting is uni-directional monotonous if it is not used in combination with other complementing techniques like indirect light, wall washing or artwork accenting. Light levels or Lux levels are only an indicative number and only one of the tools to cross check the available quantity of light. A lighting designer takes a design judgement in combination with other factors like uniformity ratio, contrasts, material reflectance and the type of task functionality to override the design. Only then a lit environment becomes qualitatively catering to an end user.

There are strategies or layers to lighting methodology for this particular spatial type, such as,

a) *Decorative lighting* — Chandeliers and other ceiling surface primarily define the design language that sets the visual tone. They provide the sense of luxury and a unique experience to the users. Contemporary decorative fixtures may also contribute to overall ambient lighting and hence may bring down the number of ambient lights that need to be used. There needs to be fair judgement on the type of lamps that can be used on these fixtures. Fixture specification decided by the Interior Designer while the lamp specification needs to be provided by the Lighting Designer. Knowledge about the overall lighting control system used is necessary in determining the lamp type that is compatible with the control system and that would have a smooth dimming curve. The Colour temperature is 2700K unless there is a design criterion that overrides the same.

b) *Artwork accenting and other feature highlights* — The opportunity for vertical illuminance is facilitated by the artwork that is mounted on the wall and the ambience of high contrast with highlights on artwork defining the tone of the space. Sculptures that form a part of the

interior design composition and able to highlighting them provides the sense of Art gallery. The Color temperature of 2700K brings out the colors used in the artwork close to Halogen source which the hospitality industry is used to in the past.

c) *Ambient lighting* — Ambient lighting judiciously designed to provide where it is necessary for a task. For different spaces, the need and quantity of ambient light differs. Care to be taken so that the contrast is not compromised and we appropriately lit spaces for the hospitality ambience.

d) *Feature wall highlight* — Lighting a feature wall is an element in the composition where it is either wall washed uniformly if it is a matte surface or backlit if it is a translucent material or wall grazed if it is a highly textured surface. The kind of lighting technique will entirely depend on the material application.

e) *Signage lighting* — Coordination to be done with other specialist consultants to incorporate signage lighting wherever applicable for wayfinding. Façade signage, area Signage and room signage are some of the examples.

f) *Specialty event lighting* — In Ballrooms or other event related spaces, where there is a need for temporary stage lighting to be done, provisions to be planned by the lighting designer to accommodate tracks that can take on theatrical spots, gobo projectors, fill light etc as per the specification of the event lighting consultant.

g) *Dance floor lights* — In bar and night club where there is a dance floor planned, the AV consultant would propose moving heads projectors and other specialty lighting equipment that is required. Lighting designer to ensure that the power / wiring is provided at the right location where these are planned or proposed.

h) *Task lighting* — Where there are seating spaces / groups in Lobby, lobby lounge, Guestroom work tables, Guestroom bedside, task lighting can be provided by the means of decorative table and floor lamps. In the Display kitchen, it can be integrated into the exhaust hood. Food Display area in F&B, task highlight can be provided with ceiling downlights or decorative pendants.

5 VISUAL IMPRESSION

The ambient definition through light gives the viewer a perception of the nature of the space or its character. Lighting sets a tone to whether the space is public, semi-private, private or intimate. A sufficiently lit space will also evoke a sense of security to the user. Lighting in a hospitality space should also aid wayfinding where the user can understand the space volume and comfortably navigate in a space they are temporarily going to use or stay. The ambience in a spa can be set to very low level high contrast, soothing and calming in character. In a ballroom can be bright, uniform, along with sparkle and celebratory in character with higher level of illuminance. Lighting in a movie multiplex or a casino can be quirky in nature where ambience can be out of the box approach with a touch of playfulness. Different

scene setting can be done to each type of space that can vary through different times of the day considering the daylight contribution and different space usage or activity.

6 QUANTITY OF LIGHT

Quantity of light is measured in Lux or Lumens per square meter which is denotes the illuminance level in the space. This is only one of the criteria and a guideline value in design but not the primary definition of how a space is lit. A user cannot directly perceive lux levels unless it is bounced off a surface with a particular material reflectance based on whether it is opaque, translucent or transparent or matte or gloss as per the characteristics of the surface finish. This is called Luminance and is measured in Candela per square meter. Understanding the function / activity of each space, the quantity of light differs per task and nature of space.

6.1 Vehicular Entry / Exit

Entry/Exit are highly secure and active zones. Hospitality and Entertainment facilities are intended for social occasion of celebration, recreation, Vacation or business related activities such as conferences, meetings. The arrival experience is the first impression for the guest. The illuminance level can also vary during the evening/night as the activity level varies. Depending on the traffic, the illuminance levels can vary from high to low as the traffic reduces.

At the Security booth area where check happens to vehicles at site entry the illuminance level can be 100 lux to enable proper scrutiny of vehicles. The driveways for hotels and resorts can maintain illuminance of 40 lux and edges well-lit and provides visual information for drivers about the peripheral definition of the driveway. Consistent visual continuity through light and lit elements suggestively leads the user to the building drop off and entry.

6.2 Porte Cochere Drop off – Building Entry

Porte Cochere drop off area shall be brightly lit so as to mark the arrival impression or glimpse of the intended space to create the anticipation for end user. Illuminance level of 100 lux is recommended which takes into the contribution of all lighting layers and elements. Three lighting layers could be used such as decorative lighting, direct lighting through downlights and indirect lighting through coves. In most hotels and entertainment spaces there are water features at arrival and they become an inherent part of the aesthetic composition.

6.3 Entry Lobby / Reception

Lobby is the visual trademark of any building type and for the hotel. It gives the impression to the guest the quality of services the operator has to offer. Typically lobby showcases luxury and sparkle in the finishes and application. Elaborate decorative fixtures and indirect lighting through coves along with minimally used ambient downlights fills the space. Additionally specialty lighting detailing that depends upon whether there are display shelves or artwork or artefacts dictates the kind of design. Typically

overall illuminance level of 150 lux can be planned taking into account the daylight contribution. Additional task lighting for the reception desk is added in to enable the working for check in process. Some additional table and floor lamps are also added for seating groups for lounge like setting and they also add for the additional task requirement.

6.4 Ballrooms

Ballrooms are typical large scale function spaces that host events. The activities here are varied in nature and each has its own lighting requirement. The functions include presentation, exhibition, demonstration, conferences, weddings, events, cocktail parties, etc. These spaces may operate as either one large ballroom or divided into smaller sections for smaller groups. These function spaces typically have large space volumes with high ceiling.

Control systems integrated into the design is important to have a change in the lighting scene per task or function. Provisions to be provided for theatrical lighting equipment. Lighting controls to be also adaptable if one large ballroom has to be partitioned to 4 smaller spaces. Typically a combination of cove lighting, downlights for ambient lighting, wall washing and decorative lighting (Chandeliers) is used.

Illuminance levels for different tasks and functions are as follows

a) Ballroom prefunction – 200 lux
b) Registration – 200 lux
c) Casual Dining – 150 lux
d) Exhibitions – 500 lux
e) Cocktail party – 100 lux
f) Meeting – 300 lux
g) Presentation – AV with notes – 50 lux (with flexibility in controls)

6.5 Meeting and Conference Rooms

These are small scale spaces that are used for meeting and presentations. The lighting to be designed in such a way that higher uniformity ratio is maintained in these areas for better performance of tasks. Ambient needs for Video conferencing tasks to also be taken care of so that there are no facial shadows all through the room and the meeting table is also adequately lit. Lighter colour finishes are also vital to bounce the light around the room. A combination of direct lighting, indirect lighting and vertical illuminance with wall washing is better for the ambience. Illuminance level for the meeting is 300 lux and Video Conference is 500 lux. Lighting controls to be designed and incorporated to adapt to different functions.

6.6 Pre-Function Lobby

Pre-function lobby is the space that leads us to the main ballroom and other smaller meeting rooms. Illuminance level of 200 lux to be maintained. Generally the event registration happens here. There could be artwork and artefacts planned into design of this lobby and lighting for the same to be planned. A

combination of decorative lighting (chandelier), direct lighting (ambience), Cove lighting (indirect) and artwork lighting is applied here.

6.7 Business Centre

This area has a few computer workstations and copier machines and other amenities required for temporary working for guests. There are few smaller informal meeting spaces that the guests can use. Simple glare free uniform lighting that enables productive work is the approach for these work spaces. Illuminance level of 200 lux can be provided. Care to be taken to use the appropriate lighting technique as there is use of backlit screens in work spaces.

6.8 Spa

Spa consists of treatment rooms where the guests need to be provided a relaxing ambience. Lighting has to make a very quiet and soft presence. It has to be conducive for undergoing treatment and massage. More than the required illuminance levels, concealed lighting detail at very low output, Ceiling recessed narrow beam spot lights wherever task lighting is required. Art accents and feature lighting detail will create the required visual ambience and restricting the usage of direct downlighting will help maintaining low ambient levels. High contrast levels with soft light throw without any glare makes perfect design ambience. Lighting controls integration into design is extremely important to switch to different scenes in every space according to its usage.

Required illuminance levels in different areas are as follows:

a) Treatment rooms – 30 lux (Designer makes a fair judgement according to design and operators requirement to override this. Illuminance levels can even be lesser during the treatment. Even basic 10 lux is enough. Quality of light and aesthetic composition is priority. Next is user preference. In case any guest wants the lights to be dimmed down even further, there should be provisions in the control panel for the same)
b) Clean up – 200 lux
c) Hammam – 20 lux
d) Changing Rooms – 50 lux
e) Sauna -50 lux (Fixtures to be IP67 rated and remote driver)
f) Steam Room – 50 lux (Fixtures to be IP67 rated and remote driver)

6.9 Salon

Lighting requirements change as per change in activity. Uniform shadow free and glare free lighting with good ambient level is required for both hair cutting and hair treatments. Whereas facial treatments require very low light soft lighting that does not hinder the comfort of the guests. Manicure and pedicure require higher light output at hand rest and footrest respectively. Mirror lighting should be provided wherever applicable so that face lighting is available face related tasks. Face lighting enables shadow free lighting on face and is always diffused in nature.

Illuminance level for each space / activity are as follows

a) Hair Salon – 300 lux

b) Pedicure – Overall 200 lux and at foot rest 500 lux
c) Manicure – Overall 200 lux and at Hand rest 500 lux
d) Facial – 50 lux

6.10 Fitness Centre

During workouts, it greatly helps if the users don't have any form of glare. It helps to combine a few lighting techniques to add in extra lighting layers to reduce the glare. Some of the equipment also are at a certain height when you use them, for example., Stair master or cross trainer. Integration of a control system into design will help keep the ambient light flexible for each task. Lighting should be flattering to accommodate video viewing and conversation. Glare from the fixtures can be avoided using lower wattage fixtures that are deep recessed with glare control accessories in place.

Illuminance level for each activity are as follows

a) Aerobics – 75 lux
b) Yoga – 75 lux
c) Group Exercise – 150 lux
d) Personal Training – 200 lux
e) Clean up – 300 lux

6.11 Restaurants and Bar

Food service is meant as the important part of the experience and hospitality for the guest. These spaces are large source of revenue and care to be taken to detail the space in lighting. There are different types of F&B outlets in five star hotels and they are All day dining, Specialty Restaurant and Bar. They differ in operational requirements and light levels depending on the food or bar services they offer. All day dining requires good ambient light level along with lighting layers and details as they operate 24 x7 and they have buffet services and live cooking areas that require higher task light levels. Specialty restaurant operates only for lunch and dinner and they have more intimate seating arrangement and some also have live cooking depending on the cuisine they serve. Bar is mostly operational in the evenings and through late night and some bars have dance floors and operate as night clubs in the late hours. Lighting design strategies should include indirect lighting, direct lighting only at the tables, buffet, live cooking counters and food display counters, feature highlights (Art, artefacts, specialised material finishes etc) and Decorative lighting (Depending on the style of the interior design). Lighting Controls to be incorporated into design to enable scene definition changes as the services differ through the day and also adapting to changes in the daylight contribution.

6.12 All Day Dining

All day dining services include breakfast, lunch and dinner buffet with live cooking all day long. The lighting is also more uniform so that it caters to changes in the table layouts. Food display needs adequate lighting highlight. Display kitchen requires good lighting to add visual drama to the process of cooking. The illuminance levels required are as follows

a) Tables – 75 – 100 lux (Morning and afternoon)
b) Tables for Evening – 60 lux (For an intimate dining setting)
c) Live cooking stations – 300 lux
d) Buffet – 300 lux (For food displays)

6.12.1 *Specialty Restaurant*

Food Services are only for lunch and dinner and generally the ambience is high contrast where the tables are pinspotted and there is negligent or no other ambient lighting other than indirect lighting slot details. More intimate dining ambience is set. The illuminance levels required are as follows

a) Tables – 75 lux (Lunch Setting)
b) Tables for evening – 40 lux (For intimate dining setting. It may also be lower depending on the design ambience as long as they can clearly read the menu.)
c) Live cooking Stations – 300 lux (Lunch setting) and 200 Lux (Dinner setting)

6.12.2 *Bar*

Very low ambient and high contrast light levels are desired in a bar. Bars are mostly operational in the evenings thorough the late night. Interior design is out of the box approach and detailing has to be thoroughly worked out to reflect the primary designer's intent. Pinspots that only lights the task tables in low output and narrow beams, is used in combination with very low output indirect lighting. Back bar work area needs lighting enough for the bartender to mix the drinks and the bottle display shelves generally have lighting incorporated with shelves. Pinspots are required at the bar counter with very narrow beams to illuminate the served drinks. Controls are very important to set each lighting layer to its corresponding ambient light level to create the perfect lighting setting. More than the illuminance levels in this context, the concept design is priority. Some guideline illuminance levels are as follows

a) Tables - 40 lux.
b) Back bar work area – 70 lux
c) Bar counter – 40 lux

6.13 Guestrooms

Guestrooms are home away from home and it needs to cater to all age groups and to people from different social strata. The lighting concept to be consistent with the overall design of the other public areas in the hotel. The lighting effects will also depend on the rating or the type of hotel such as Five star hotel, resort, business hotel or budget lodging. Lighting must satisfy the common needs of living such as reading, working, tv viewing, night light, bathing, dressing up and so on. Artwork is also a part of overall design and accenting them creates a rich ambience and makes a difference to overall outlook of the space. Reading lights to be provided for bedside reading and these can be either special gooseneck fixtures with medium beam spread or table lamps with soft diffused light throw. Task lighting at the working desk either by ceiling downlights or floor lamps depending on the design. Mirror lighting in vanity counter to be planned in such a way that the wash basin counter has downlighting and there is side lighting (diffused light) for the face to enable the task of make up or shaving. There are also mirrors that are available with integrated lighting that is backlit behind embedded frosted glass that is a part of the mirror. Lighting needs to be provided for the luggage rack and linear lighting needs to be

incorporated inside the wardrobe to provide adequate lighting for the guests to pick their clothes. Wardrobe lighting is generally connected to a door switch. Lighting inside a shower to be IP54 rated for damp protection.

Lighting controls to be planned in such a way that each task has a particular setting like reading, working / study, TV, night, Master off. Simplified lighting controls are better that the guest, during his temporary stay feels that it is easy to use and comfortable.

Executive and presidential suite will have additional spaces and requirements such as separate office space, lounge, dining, pantry etc. Strategies similar to residential lighting can be adopted and refer to Residential lighting section of the NLC code.

6.14 Public Circulation

Public Circulation includes the elevator lobbies, corridors, etc. Most of the ambient lighting quotient is indirect and direct lighting is mostly in even wide beam to illuminate the area with uniformity. Entry exit points to rooms or various other public spaces to be clearly visible and it can have downlights illuminate them appropriately. Facial recognition is important along with other aesthetic considerations. Lighting for basic safety is important as well. Guide illuminance level of 100 lux can be provided considering other aesthetic overriding factors. Artwork lighting and other feature highlights form the vertical illuminance quotient.

6.15 Public Toilets

Soft overall indirect ambient lighting along with pinspots over the wash basins is the generic application in lighting. Other interior design related decisions may over ride this. There could be onyx or other translucent material that is backlit to provide soft diffused glow, but this is subjective to design. Face lighting to be considered in the Vanity so that it enables guests to do their make up. Face lighting can be achieved by diffused lighting by the side of the mirror by a wall sconce or mirror with integrated diffused lighting is available that can be provided.

6.16 Pool and Pool Deck

Lighting inside the swimming pool needs to be planned well ahead of time and back boxes and conduiting needs to be IP68 protected. Water proofing should never be compromised. Lights to be mounted about 450mm or 18” below the water level and lighting inside the pool needs to be uniform to ensure that there is good visibility inside the pool for basic safety. There will be a light depreciation inside the water due to the refractive index in water which needs to be accounted for during the calculations. Depending on the tile colour and finish inside the pool the output of the light source can be selected. Low level soft lighting can be planned around the pool deck by tree uplights or other feature highlight that throws indirect lighting to the surrounding. Any water jets or water spouts also need to be lit as feature highlight. Design should ensure that there is no dark corners or dark patches for safety. Illuminance levels of 50 lux around the pool deck is sufficient with good uniform throw. Lighting design should reflect the ideas in the landscape concept.

7 ENTRANCE

The illuminated exterior of the building is identified at night from afar as a place of hospitality that does more than just boosting the prestige of the hotel by guiding guests swiftly and easily to the door especially in an unfamiliar environment. This makes an agreeable impression and leaves behind a pleasant long - term memory. However, night lighting finely tuned to the architecture also has an enduring positive impact on the image of the establishment.

The lighting design approach should consider the location, the luminaire positions and mounting height and the shielding and the controls required to match the theme and blend with the neighborhood. For hotels which have landscaped entry drives, lighting leading to the entry and surrounding landscape is both important and should be taken into consideration and can in fact enhance the aesthetic. The lighting design for the entry to the hotel should not create any light pollution or light trespass onto the neighboring properties. These are the areas where the aesthetic is important but also the guest should be able to see their bearings. The glass façade can be used to welcome guests with the use of proper bright illumination of walls, surface illumination of interior ceilings and enhancing the artwork. The porte-cochere area of the entrance acts as a transition area for illumination levels of outdoor and indoor and while designing proper lighting control should be incorporated in the design to adjust to varying light levels corresponding to day/night cycle.

The choice of luminaire may largely depend on the available budget but should be white with high color rendering index so that people, cars and objects looks their best. It will be a good approach if the lighting design consider some luminaires that can be used to accent and sparkle some key features.

8 LOBBY

This is the soul of the hotel in which hotels welcome their guests for the first time presenting the hotel momentum as this is the most multifunctional area. These areas play an important role for the success of the establishment which in turn gives the hotel the opportunity to express its uniqueness as a brand and thus is the place where all the emotional, aesthetic and practical aspects of the design meet. It creates a favorable impression of the hotel.

In hotel lighting design, the lobby needs to present welcoming atmosphere and makes people feel at home and hence the initial impact on guests is particularly important. The reception desk and lobby should instantly entice the guests to come closer, invoking a sense of a warm welcome. Successful lighting design that creates a comfortable, attractive yet functional space and reinforces the mood set by the interior design becomes an important marketing tool.

Lobbies are generally used for reception desk area along with other uses as:

a) The lounge or waiting areas

b) Service areas

c) Newsstands

d) Elevator lobbies

e) Shops

f) Specialty stores

g) Art galleries

h) Restrooms

Each and every areas requires pleasant and sufficient lighting which not only emphasizes the architectural concept of the hotel also ensures that the task can be accomplished successfully.

They form a link between outdoor areas and the inside of the building. The lighting design should include a transition area to increase the visual comfort and allow guests to adapt from outdoor light level to indoor light level. The layout and appearance of the lobby in general should be easily understood. Special considerations should be given to avoid any potential hazards due to sudden change in elevation with the help of lighting to make navigation easy and safe.

The main purpose of the lobby area being the centers for information and communication, this area should have lighting support for functions like allowing guests to easily read documents and maps and handle currency, which may be unfamiliar to traveler from overseas.

9 STAIRCASE AND ELEVATOR LOBBIES

Staircase have to be safe for those who use them and hence much care needs to be taken while designing the lighting needs so that no treads are obscured by shadows. To make for safe visual conditions on a staircase there must be risk of luminaires causing glare or distracting attention. The lighting design for staircase calls for the illuminance provided is right for the reflectance of the material used. A low-reflectance surface requires a high intensity of light to achieve the same brightness as that of a high reflectance surface with low level of illumination. Thus it is important that the brightness and color of the floor surface is defined before a lighting design is prepared. It is also to be noted that highly reflective surfaces have a significant bearing on the economics of lighting design.

In any emergency situation the staircase acts as an escape route and hence escape route lighting should be incorporated in the lighting design plan along with its maintenance.

The lighting design of the elevator lobby should satisfy its functional demands along with maintaining the harmony of the look from the main

lobby conforming with the basic structure of the building. In this area sufficient lighting is to be provided so that the elevator panels are easily readable and also even outside the elevator doors, a greater sense of security can be promoted. Inside the elevator, the color scheme of the lighting should be bright and diffuse in order to avoid any hard-edged distorting shadows on the faces of the elevator users.

10 CORRIDORS

Corridors need to be regarded primarily as circulating spaces for hotel guests to and from their rooms, lobbies, restaurants, ballrooms, shops, meeting spaces, recreational areas. Efficient and proper artificial lighting can reduce the “tunnel effect” arising from the impression of depth due to the interior and make the space more efficient, pleasant and safe.

Corridors also act as escape routes in the time of emergency and hence proper escape route signage and lighting needs to be maintained.

Proper lighting allows hotel guests to find their destination quickly and easily. Signage should be attractive, legible and easy to interpret and properly placed to identify the respective places used for public function. Also this is the area where hotel staff also spend a great deal of time so it is very much necessary that the lighting levels are adjustable to their comfort in order to facilitate working efficiency.

Since most of the time the corridors inside the hotel are long and closed and lacks natural lighting it is crucial to avoid uniform, homogeneous lighting system and instead opt for an interesting landscape with differing luminance levels. Room numbers should have backlit or proper illumination so that it is easily visible by guests to get their bearings. The lighting design for public corridors should fully consider the whole design style to convert a plain public corridor into an interesting diversified gallery along with the usage of appropriate luminous color and luminance. As these are the areas where the luminaires operate around the clock the lamp life and lumen depreciation should also be considered. Intelligent hotel lighting control is recommended due to intermittent occupancy of the public corridors.

11 FOOD AND BEVERAGES

Restaurants and bars within the hospitality environment is not only complex but also energy extensive. Lighting must emphasize the authenticity of the event be it a stylish bar or an atmospheric lounge or be it traditional, cool or an exotic event. Light should not only highlight the specific character of the space it should also relate to the mood of the guests.

The guests may still be tense from the stress of the day and they want to relax alternatively, they may wish to create a border around themselves – but yet be open for others and new things. And this is the place where intelligent lighting accommodates both the needs. The lighting designer needs to pay attention to the color rendering index of the luminaires as this is very much important for ensuring the freshness and delicacy of food that is being served. Depending on the type of the restaurant and intended clientele, lighting can vary the mood from subdued and relaxing to bright and lively.

Food displays should be lighted so that they draw customer's attention and allow them to clearly see the details of the food. The amount of heat generated from the luminaire to highlight frozen, fresh or colored food should also be taken care of. The lighting design for bars are precisely based on the analysis of the groups the establishment wishes to attract and depending on this the luminaire type is considered. The bar counter and shelves with beverages are highlighted and eye-catching, accentuating the products offered. The guests whether seated or standing are bathed only in minimal light and great care is taken to avoid glare. Well shielded downlight can produce a pleasing sparkle on specular objects such as glassware and also provide the needed illumination to read menus. Good lighting should always just be perceptible but not prominent.

Colored light and programmed color changes can be used to create atmosphere. Escape route signs and escape route lighting need to be installed and maintained.

Now a day many restaurants and bars have visible kitchen area known as exhibition kitchens. The lighting design for these areas are critical since they are just located adjacent to dining areas with subdued lighting leading to the need for control of glare and source luminance.

In the case of quick – service restaurants the lighting designers can go for high level of illuminance and uniform distribution as in this case both the diners and the management are intent on both fast service and quick customer turnover.

12 GUEST ROOMS

Whether it is a short trip, business trip or long vacation, guests want to feel at home. Now the guest room has multiple functions like eat, sleep, work - not just a room to sleep.

Hotel rooms and suites have a wide variety of function zones for working, reading, watching TV, resting, sleeping, etc. The lighting design should also be multifunctional. Since the illuminance required depends on the reflectance of the surfaces of walls, ceiling, floor and furniture it is important that lighting design is planned with the interior décor in mind. If the luminance differs too much inside a room the human eye has to adjust multiple time which leads to fatigue. The lighting design should consider a balanced modelling with soft brightness contrasts. On the contrary if the modelling is too little it impairs 3D vision and makes for visual monotony and if deep shadows then it creates an impression of dynamism.

To enhance the overall impression made by the room, quality of design should be a priority when selecting luminaires. While selecting low – energy light sources to provide the appropriate quality and quantity of light it is important to pay attention to the color of the source and as well as its ability to turned on instantly and reach full intensity quickly. Lighting designer should take account of the theme of the hotel in choosing luminaires for the multiple uses of the space.

Guests need to be able to select and regulate the level and distribution of brightness in the room to suit their mood. There will be a single conveniently placed switch either at the entrance of the room or at the bedside to control and regulate the light level and can also be used to turn off the lighting load when the room is not occupied. Controls that are straightforward and intuitive allow every guest to adjust the light to their preferences in a quick and easy manner.

Since the guest should feel like home where they are most comfortable it is recommended soft illuminance in the rooms, leaving stronger accent lights for the central living areas. The functional and bright lighting zones in the room is necessary but not at the cost of the well-being. The partial lighting for toilet mirror, bed light, etc. can apply abundant illuminance. The angle of the bed light should be so arranged not to interfere with the other guest's rest. This bed side lamps for reading should have a good CRI with CRI of 90 or higher. In case of any mirrored doors the lighting design should not consider any luminaire specific to that area which may cause glare yet maintaining the décor and theme of the design. The design should have scope for low level nightlights to illuminate the paths from beds to the bathroom and the best color for this is Red or Amber as this has shown less sleep disruption with human clock.

Now a day a typical hotel guest room has a desk with internet connection and task lighting addressing the business need of the guest. Task lighting can be provided with the solution of table lamps or portable and/or adjustable desk lamps providing the flexibility for a number of tasks. The choice of the light source should be energy efficient along with proper shielding and source coverage to avoid any glare on specular laptop screens.

Multilevel illumination not only provides variety of illumination levels for guests but also allow energy reduction

13 SPAS

Term is derived from the name of the Belgian town of Spa, where since medieval times illnesses caused by iron deficiency were treated by drinking chalybeate (iron bearing) spring water.

From the hotel point of view this is just the area for relaxation, massage and meditation. The qualities that are sought by Spa are inviting, relaxed, re-energizing and healthy. The ambient lighting should be such that it prepares the guest for the spa experience to come by flattering a person's sense of personal appearance. This can be achieved by establishing a home like space and incorporating higher color rendering sources min CRI of 90. The lighting design with its illumination levels, colors, and/or decorative effect should assist and point the guest from the entry to the registration leading to the treatment area.

The lighting in the Spa lobby should excite the guest for the experience to come and also provide the illumination for relaxation. Warmer co-related color temperature of 2200K to 2700K and lower light levels are preferred for this. While designing the lighting care should be taken about the theme and also to minimize "bleed" from the cool color tones into areas deserving of warmer colors.

In the spa treatment rooms, the lighting design should consider the light for the employees performing this detail work. Low glare fixtures and those that reduce hard shadows and high contrasts are strongly encouraged. Thus direct overhead sources are discouraged for these detailed task otherwise used if required for the cleaning purpose.

The lighting in the spa locker area should reflect the activity and feeling of social gathering and safety. Luminaires providing no glare and high vertical illuminance provides guest the ease of accessing the lockers. Indirect lighting with softer quality and no glare along with high CRI value provides a further relaxation to guests complementing their complexion. The transition areas from the locker room to the treatment rooms or towards the lobby should be well illuminated to emphasize a sense of room transition and passing-through experiences.

14 FITNESS CENTER

Fitness centers in hotels can range from rooms that has been converted to gyms to fully equipped gym areas. These spaces generally include equipment like treadmills, weight machines as well as stationary bikes. There may be additional spaces for specialty sports activities and studios. The lighting design in the fitness center should provide even illumination. Indirect shielded lighting sources is preferred to avoid any kind of glare as most of the exercises happens from a horizontal position looking up and also due to the availability of many reflecting surfaces like mirrors. Recessed luminaires, indirect coves and decorative – trim downlights provide good solution that shield the source. The mounting height of the luminaire should also be taken care of as few equipment's come with the option of elevation.

Studios can go for an option where they can use multiple lighting scenes or dynamic lighting scenes synchronized with music or fitness schedule.

The lighting design should also incorporate daylighting if available in order to have an option to save energy when daylight is there.

In facilities with ceiling fans the luminaire placement should be considered carefully in order to avoid any stroboscopic effect caused by moving shadows of fan blades cast by lights placed above.

15 POOLS

In today's health- and leisure-oriented society, pools and saunas, activity zones and rest areas are considered an intrinsic part of the modern hotel service package. The lighting design for hotel pools can be equipped with spot luminaires that not only enhances the visual impact of a pool, but also intensifies the effect by lowering the brightness of the surroundings. The lighting design should consider most importantly the lighting levels on the deck sides of the pool with a high CRI and a lux level of min 100 lux.

Reddish tint i.e., yellow, orange, red, violet light is avoided because water becomes unpleasantly colored. Also greener tones may make the water look dirty giving a visual impact of unhygienic. Instead brighter lighting and neutral light colors reinforce the impression of a high standard of hygiene and cleanliness.

BUREAU OF INDIAN STANDARDS

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Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 6 Lighting for Retail Premises

[First Revision of SP 72 (Part 5/Section 6)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49	**Last Date for Comments: 06-June-2024**

FOREWORD

The lighting system shall be meticulously designed to create a pleasant and secure environment for business. Attention shall be given to the quality, quantity, and effectiveness of lighting and its ability to render colors in the displayed merchandise.

Achieving sustainable retail lighting design is possible with providing the required visual comfort conditions, ensuring users' psychological and physiological satisfaction, energy efficiency, sustainability, and optimum cost considerations.

Employing advanced lighting control technologies and incorporating daylighting in retail environments endows a building with a distinctive quality, creating a dynamic ambiance that positively influences the mood of both staff and customers.

1 SCOPE

This section covers lighting requirements in the in-store environment, primarily focusing on merchandising techniques and activities.

2 REFERENCES

EN 12464-1: 2021 - Lighting of indoor work places

IESNA Lighting Handbook 9th Edition.

3 FACTORS TO BE CONSIDERED IN RETAIL LIGHTING

3.1 Visual Comfort Criteria in Retail Lighting Design

Light directs, informs, shapes and forms. Three visual parameters determine these effects:

a) *Visual Performance* — Is a measure of the speed and accuracy with which things are being recognized. For shoppers, adequate lighting level and good glare limitation are prime requirements, enabling merchandise to be easily identified and inspected.

b) *Visual Atmosphere* — Describes the overall impact of an interior and the emotional, motivating appeal it has on customers. The lighting planner must give prime consideration to the colour appearance of lamps, luminance, distribution of light and shadow, and luminaire design.

c) *Visual Comfort* — Denotes visual performance under agreeable conditions. "Comfortable" lighting underpins the layout of a salesroom and even activates the shoppers' - Supplier-steered - passive attention, requiring them to draw on memory, experience and powers of concentration. Accurate colour rendering, balanced brightness distribution and high vertical illuminance levels are key lighting quality requirements.

3.2 Criteria for Visual Comfort Conditions

3.2.1 *Illuminance Levels* — Maintained illuminance level for retail environments differ according to the type of the retail environment. Therefore, lighting design of each retail environment shall be performed considering the specific retail environment's requirements and the shop profile. Illuminance criteria for retail environments is presented in Table 1.

Table 1 Illuminance Criteria For Retail Environments

(Clause 3.2.1)

Sl. No	Shop Profile	Eave Range (Lux)
(1)	(2)	(3)
i)	budget shops (without accent or display lighting)	500 to 1000 lux
ii)	shop with an exclusive profile (Widespread use of accent and display lighting)	300 to 500 lux
iii)	shops with value for money and quality profiles (with accent lighting)	200 to 300 lux

3.2.2 *Luminance Distribution* **—** The luminance distribution in the visual field controls the adaptation level of the eyes, which affects task visibility. Therefore, a well-balanced adaptation luminance is required to increase visual acuity (sharpness of vision), contrast sensitivity (discrimination of small relative luminance differences), efficiency of the ocular functions (such as accommodation, convergence, pupillary contraction, eye movements, etc.). For retail environments, luminance distribution is very effective on the strength of accent lighting where different sorts of luminance ratios can result in diverse strength of accenting.

Luminance Ratio is contrast between object and background. It can be evaluated by Accent Factor.

Accent Factor = Illuminance at Object/General Horizontal Illuminance

Varied Accent factors yield different visual effects. An Accent factor of 2 begins to show noticeable effects, while at a value of 50, the impact becomes significantly dramatic. The examples of Accent factor v/s their visual effects are given in Fig. 1.

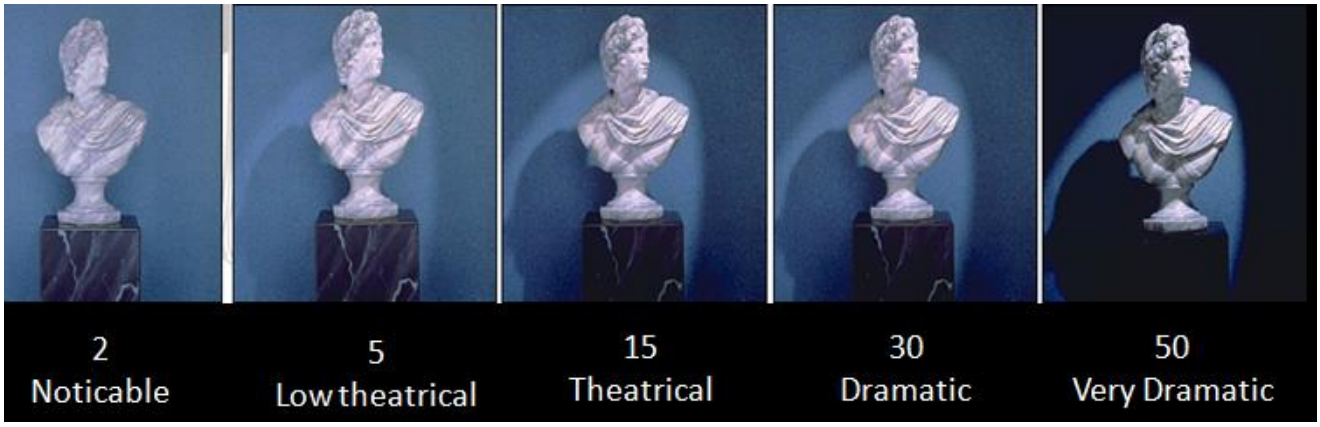


Fig. 1 Accent Factors V/S Their Visual Effects

3.2.3 *Glare* —The luminance distribution in the visual field affects visual comfort conditions. In the lighting design of retail environments, control of glare is a necessity to perform the required visual comfort conditions. Maximum UGR (Unified glare rating) limit typically range from 19 to 22 for retail environments. Recommended UGRL values for retail environments are given in Table 2.

Table 2 Recommended UGRL Values For Retail Environments

*(*Clause *3.2.3)*

Sl. No	Application Area	Ugrl Value
(1)	(2)	(3)
i)	Sales area	22
ii)	Till Area	19
iii)	Wrapper Table	19

3.2.4 *Color Considerations in Lighting Design for Retail Environments* — In the lighting design phase for retail environments, the following aspects should be considered in terms of colour:

3.2.4.1 *Correlated Colour Temperature (CCT***)** *in Lighting Design for Retail Environments* — CCT selection depends on classification of retailer, quality of merchandise, client preference and designer preference. It is common that the colour appearance of the light sources used in retail environments change from cool to warm as the shop profile moves from low budget to exclusive. Colour considerations are determined by the nature and the special properties of the displayed merchandise, as

well as the branding characteristics. The color parameter is also a factor, affecting the lighting performance especially in the finishing material selection phase. In other words, the light reflectance value of the surface materials should be selected studiously. The ranges of useful reflectance's for the major interior surfaces are 70% - 90% for ceiling, 50% - 80% for wall, 20% - 40% for floor.

The guidelines provided in Table 3 highlight the significance of Color Rendering Index (CRI) and Correlated Color Temperature (CCT) in display areas, and emphasize the importance of managing glare in cashier areas. Circulation areas generally require less attention in these aspects. However, some retail shops may find it necessary to address all these key points, even in circulation areas.

Table 3 Lighting Guidelines For Various Retail Areas

(*Clause 3.2.5.1*)

Sl No.	Important Design Factors for Retail Lighting	Feature Display	General Retail	Cashier	Circulation
	Color Rending Index/Color Temperature	●	●	◐	◐
i)	Contrast/Accent/Highlight	●	●	◐	◐
ii)	Daylighting Integration/Control	●	●	●	
iii)	Direct Gale/Reflected Glare	●	◐		○
iv)	Image or Style	●	◐	◐	◐
v)	Modeling of Object/Shadow	●	◐	◐	○
vi)	Visual Priority/Organization	◐	◐	◐	◐
vii)	Quantity of Light on Vertical Displays (fc)	◐	◐		
viii)	Quantity of Light on Horizontal Surfaces (fc)	◐	◐	◐	◐
ix)	Aiming Flexibility of Accent Lighting	●	○		

● Very Important ◐ Important ○ Somewhat Important

MOST IMPORTANT DESIGN FACTORS FOR RETAIL LIGHTING	Feature Display	General Retail	Cashier	Circulation
Color Rendering Index / Color Temperature	●	●	◐	◐
Contrast / Accent / Highlight	●	●	◐	◐
Daylighting Integration / Control	●	●		
Direct Glare / Reflected Glare	●	◐	●	○
Image or Style	●	◐	◐	◐
Modeling of Objects / Shadows	●	◐	◐	○
Visual Priority / Organization	◐	◐	◐	◐
Quantity of Light on Vertical Displays (fc)	◐	◐		
Quantity of Light on Horizontal Surfaces (fc)	◐	◐	◐	◐
Aiming Flexibility of Accent Lighting	●	○		

● Very Important ◐ Important ○ Somewhat Important * Adapted from the Lighting Design Guide. IESNA Lighting Handbook, 9th Edition

Fig. 2 Effect of Different CCTS on Window Display

The images in Fig. 2 demonstrate how a window display can be illuminated with different correlated color temperatures (CCTs), highlighting the color and texture of the merchandise. Since lighting is a subjective matter, the perceived effect will be determined by how the brand wishes its products to be perceived — whether as formal or cozy, classy or rugged, elegant or edgy. This perception is highly dependent on the brand and the type of merchandise being showcased.

3.2.4.2 *Colour Rendition* **—** Color Rendering Index is the quantitative measure of the ability of a given light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source. The higher the CRI value of a light source, the more accurate the color appearance of a given object.

A new metric, TM-30, has been developed as a quality metric to complement and eventually replace the old CRI (CIE) metric for assessing the fidelity of a light source.

The new TM-30 offers two metrics Colour Fidelity (R_f) and Colour Gamut (R_g).

a) *Colour Fidelity (R_f)* —It is used to measure the light source's closeness to a reference source. Colour fidelity is like CRI however references 100 swatches rather than 8. In Fig. 3, three light sources are compared for various values of R_f. The center source exhibits a high R_f (>90), indicating minimal color distortion. As a result, the TM-30 icon displays very short arrows, which indicate the extent and direction of color distortion. The source on the right makes green and red colors more saturated, evident in both the image and on the TM-30 color icon (whose arrows point outward, towards "more saturation"), its gamut index Rg increases, but its fidelity index Rf decreases due to color distortion. Conversely, the source on the left desaturates greens and reds, and has low values of R_f and Rg

b) *Colour Gamut (R_g)* — describes colour gamut which means whether colours are, on average, under-saturated (low gamut) or over-saturated (high gamut). R_g measures the average gamut shift (hue/saturation) of the source is the average level of saturation relative to a reference illuminant (measured between 60 and 140).

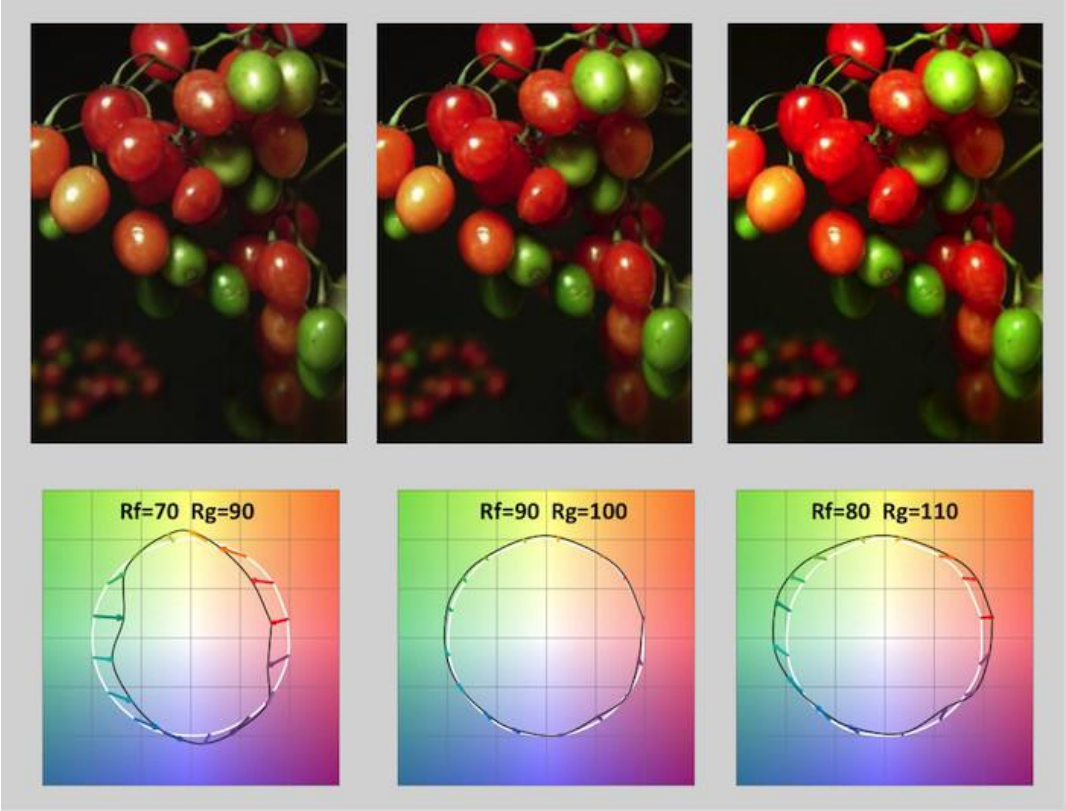


Fig. 3 Light Source R_f Comparison

4 TYPICAL SHOP PROFILES

Retail premises differ on four dimensions as presented in Table 4. It is the position of four dimensions that determine the shop profile.

Table 4 Four Common Shop Profiles

(Clause 4)

Sl. No	Shop Profile	Price	Usage	Product Range	Sales
(1)	(2)	(3)	(4)	(5)	(6)
i)	Low Budget	Bargain	Weekly	Wide	Self Service
ii)	Value for money	Low	Daily	Limited	Social contact
iii)	Quality	Higher	Impulse	Wide	Shopping as fun
iv)	Exclusive	Expensive	Deliberate	Exclusive	Personal service

Shop profiles are significant as they dictate various lighting styles. These profiles include:

a) Low budget shops tend to be big box stores using high level uniform general lighting with no accent or display lighting (*see* Fig. 4)
b) Exclusive shops tend to be much smaller and use low levels of general lighting combined with strong accent and/or display lighting on the merchandise (*see* Fig. 5).
c) Value for money and quality shops lie between these extremes, with both general lighting and some accent lighting being used.

Fig. 4 A 'Budget' Retail Store

Fig. 5 A High End Retail Store

4.1 Sales Areas

Retail spaces should facilitate the initiation and completion of sales transactions. This requires adequate overall or general lighting. The lighting in the sales area should ensure safe and unimpeded movement for customers. Fig. 6 represents a Typical Sales Area Lighting Sample. Lighting in the sales floor can be achieved through downlights, track lights, or cove lights. Several factors should be considered in the design of sales-area lighting, including:

a) Type and characteristics of merchandise
b) Merchandising strategies
c) Location of each merchandising area within the store and at outdoor areas
d) General illuminance level
e) Illuminance levels of adjacent spaces
f) Feature and display illuminance levels
g) Size and shape of space
h) Surface reflectances, colours, and textures
i) Flexibility requirements
j) Size and location of graphics
k) Method of display (racks, gondolas, and counters)
l) Method and location of sales transactions
m) Location of merchandise displays including feature displays
n) Traffic patterns

Fig. 6 Typical Sales Area Lighting Sample Image

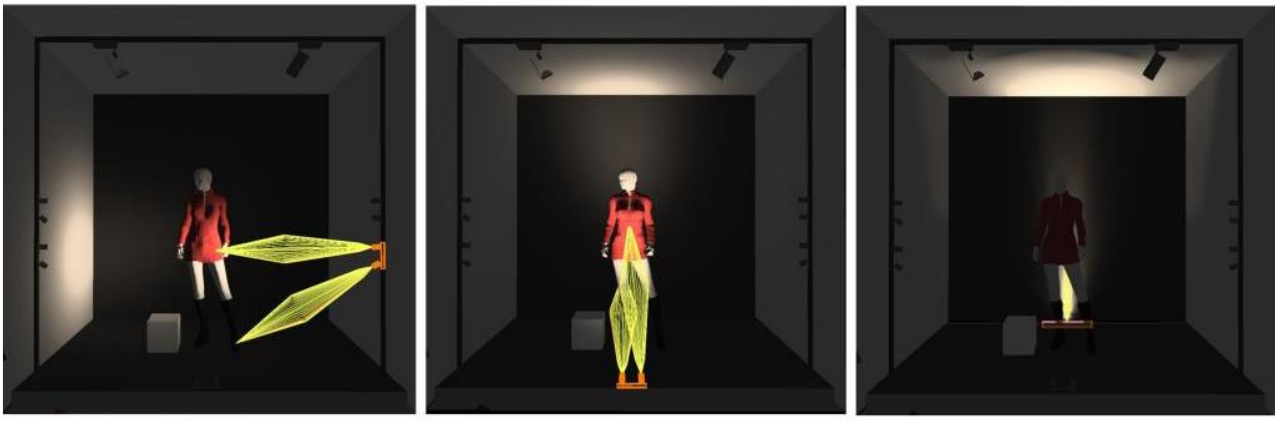
4.2 Show Windows

The shop window serves as a bridge between potential customers passing by and the merchandise displayed within the store. To effectively draw attention and minimize the impact of reflections that may obscure the merchandise, the lighting in the shop window should be brighter than the ambient conditions. When considering daylight, it is important to account for sun angles and shadows. Installing dimming and/or multistep ON/OFF controls for the electric lighting can aid in addressing the highly variable nature of daylight. This ensures that appropriate illuminance levels are maintained, particularly during nighttime conditions. An example of different combinations of window display lights is presented in Fig. 7.

Each of the following factors should be considered in the design of show-window lighting:

a) Location of show window (outdoor or enclosed mall area, urban or suburban, solo or shopping centre)
b) Night and day use and associated ambient illuminances
c) The nature of the overall competition as well as adjacent show windows
d) Fully enclosed or open back configuration
e) Size and shape
f) Reflections, contour, and slant of show window glazing
g) Architectural canopies, jalousies, or louvers
h) Interior surface reflectance’s and colours
i) Size and location of display graphics

Spot Beam **Flood Beam** **Flood Beam From Sides**



Flood Beam from Sides **Flood Beam From Top** **Wall Washing**

Fig. 7 Sample Display Window Lighting Combinations

The display window presents an ideal canvas for crafting captivating light scenes. With changing seasons and occasions, diverse lighting solutions become essential to maintain the excitement of the window display.

When integrating daylight and light scenes into the display window, ensure the incorporation of lighting controls. This not only saves energy but also reduces the lumen output of the luminaires, particularly during peak daylight hours. An example of Show Window display Lighting Image is presented in Fig. 8.

Fig. 8 Show Window Display Lighting Image

4.3 Dressing and Fitting Room Lighting

The dressing and fitting room area in a clothing store is one of the most critical sales areas, as it represents the final stage for customers to evaluate merchandise before making a purchase decision. Fitting rooms are typically equipped with a bank of individual dressing rooms, along with a fitting area or a larger dressing room where a tailor or seamstress can assist with measurements and fittings for tailoring or alterations.

The design of dressing rooms can vary significantly. In discount or warehouse stores, they may be simple and semi-private. However, upscale stores often feature elaborate, large, and private rooms that include amenities such as sofas, chairs, portable luminaires, and refreshment areas. These upscale dressing rooms not only provide a comfortable and luxurious experience for customers but also contribute to the overall ambiance and image of the store. Sample images for fitting rooms lighting application are presented in Fig. 9.

a) Lighting this space requires the utmost sensitivity from the designer to ensure appropriate vertical illuminance, good colour rendering and the elimination of harsh shadows. Modelling of faces and colour appearance is important.
b) Lighting solutions should provide a combination of diffuse and directional light to accentuate facial features and fabric texture without deep shadows. Vertical illumination should extend far enough down to enable the customer to easily evaluate full-length garments.
c) Careful choice and placement of overhead luminaires adds to colour vibrancy, texture enhancement, and sheen or glitter of hair and materials and can create modelling effects.
d) Lighting at the mirror should be used to complement and soften facial shadows without reflected glare. The luminaire should be positioned to light the customer standing in front of the mirror,

rather than the mirror itself. The light source should be diffuse to minimize shadows and the colour quality of the source is crucial.

e) Background finishes should be light coloured, matt and simple in design to avoid colour distortion or distraction from the merchandise.
f) The proper angle of illumination is especially important for mirror lighting. Ceiling luminaires should be placed at the mirror wall or mirror lights should be located above the mirror. Direct downlights over mirrors should be avoided.
g) Downlights tend to create unflattering shadows that result in an unattractive and undesirable view for the customer. If downlights must be used, wide-distribution luminaires are preferred, equipped with led lamps.

Fig. 9 Sample Images For Fitting Rooms Lighting Application

4.4 Wrapping and Packing Area

In addition to wrapping and boxing the customers' purchases, sample gift wrap displays are featured in this area.

a) The wall immediately behind the work area should have a reflectance above 40%. This reflected light is necessary to provide both good illumination on the task plane and uniform brightness for eye comfort.
b) Ambient illumination should be uniform for the worker who faces into the room.
c) The luminaires should be positioned to avoid reflected glare from glossy materials at the user's normal position, unless reflections are desired for some special application.
d) Ceiling-mounted or suspended wide-distribution luminaires arranged over work areas provide uniform illumination. Adjustable spot lights provide added directional lighting for special conditions.

4.5 Cashier Areas

Cash counter is the final encounter of the customers to sales staff. Lighting must help the staff to do their task, eliminate errors in giving change or punching the right item to cash register. This is also the last time that the customer will check the merchandise. Therefore, lighting must have the right level for reading, writing, checking colors and fabric. The luminaires can be suspended, or they can be recessed in a canopy or lower ceiling area above the sales counter as shown in Fig. 10.

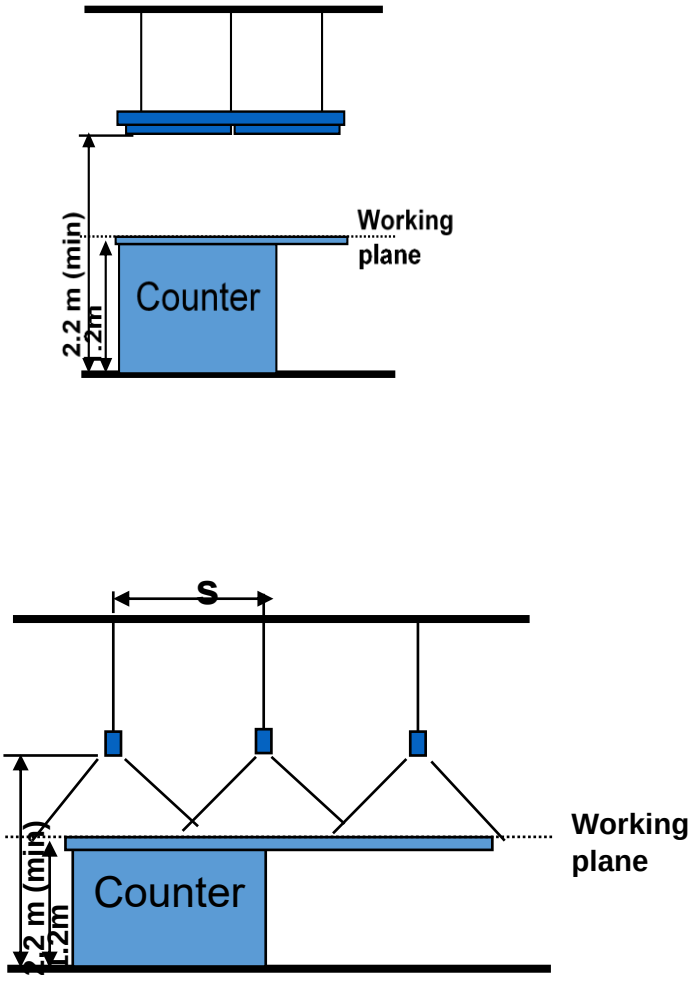


Fig. 10 Lighting Options for Sales Counters

Lighting should aim to provide even cylindrical illuminance, as depicted in Fig. 11, to showcase the friendly faces of the sales staff. This type of lighting creates a welcoming ambiance that helps customers feel more comfortable.

a) 500 lux with good color rendering (at least 80 CRI) must achieve at the top of cash counter.
b) Suspended luminaire helps the cash counter to be easily recognized. Track light or downlight is also possible to use if the cash counter is brighter than the selling area.
c) For the cashier area, use luminaires in a horizontal plane parallel to the working area. These are often suspended from the ceiling to bring them close enough to the working surfaces, but they should be at a minimum height of 2.2 meters over the surface to ensure enough freedom of movement for staff and customers with the products they have purchased.
d) For the counter area the same minimum height of 2.2 meters applies but here the required accent lighting is usually provided by compact, unobtrusive point light sources (nothing to hinder interactions between sales staff and customers)

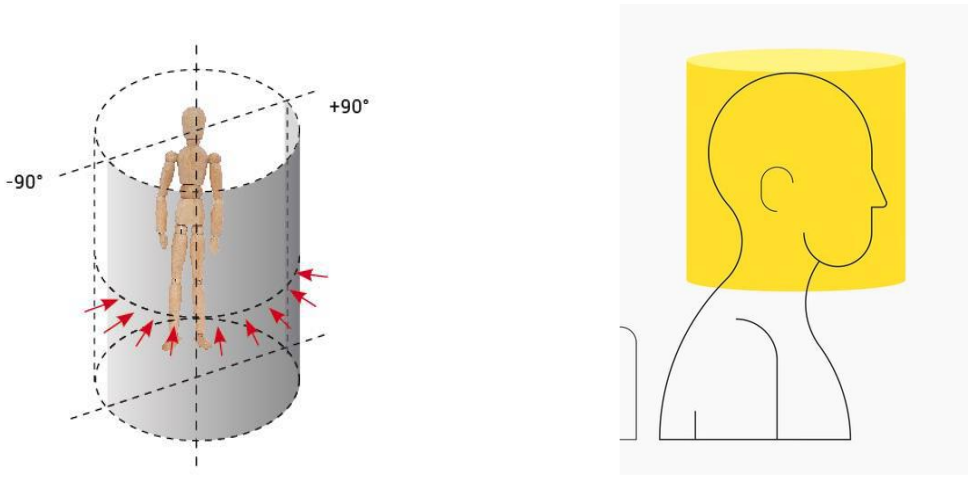


Fig. 11 Enhancing Customer Comfort With Cylindrical Illuminance

4.6 Restrooms and Waiting Lounges

Lighting for customer restrooms and lounges must be practical and aesthetically pleasing. Design of restroom counter and mirror lighting should follow the design concepts discussed above. However, restroom lighting systems need not be as elaborate as those for dressing and fitting rooms.

5 TYPES OF LIGHTING TECHNIQUES IN RETAIL ENVIRONMENT

5.1 Ambient/General Lighting

In a retail environment, the ambient lighting system should deliver a consistent, diffuse layer of illumination throughout the store. It's crucial that the lighting not only creates a welcoming atmosphere but also guides customers along specific paths, directs their attention to key areas, and enhances their awareness of the products available. Good lighting helps shoppers orient themselves and navigate the store effectively.

a) Often referred to as the "general" lighting, the maintained average ambient light level can range from low (30 to 300 lux) to high (500 to 1000 lux) levels depending on the store image.
b) Luminaires used for ambient lighting are typically arranged symmetrically with broad light distributions. The chromaticity and colour rendering quality of the lighting can vary based on the target market and the overall store concept. Integrating daylight into the lighting design can also be crucial for creating a vibrant and inviting shopping environment.
c) Carefully planned arrangements of luminaires within the room, strategic zonal grouping of light sources, and the effective use of light and shadow guide customers' footsteps.
d) General lighting is typically achieved with downlights, providing direct illumination. This direct lighting creates a degree of modelling on the illuminated objects, which can vary in intensity depending on the directionality of the lighting. For example, directional lighting will produce stronger modelling effects, while diffuse lighting will result in softer modelling as shown in Fig. 12.

Fig. 12 Ambient Lighting Application Image

e) To achieve uniform lighting, luminaires are positioned in a regular arrangement, either in groups or rows, across the entire ceiling area. These luminaires can be recessed or semi-recessed into the ceiling, surface-mounted on the ceiling, suspended from the ceiling, or even designed to shine down through it, creating a luminous ceiling effect (*see* Fig. 13).
f) Wide-beam luminaires are recommended to avoid harsh shadows and provide flexibility in illuminating the entire area effectively. Narrow beam luminaires have a higher chance of missing objects or racks that require illumination. Wide-beam luminaires also help maintain a good balance between horizontal and vertical illuminance levels enhancing overall lighting quality.

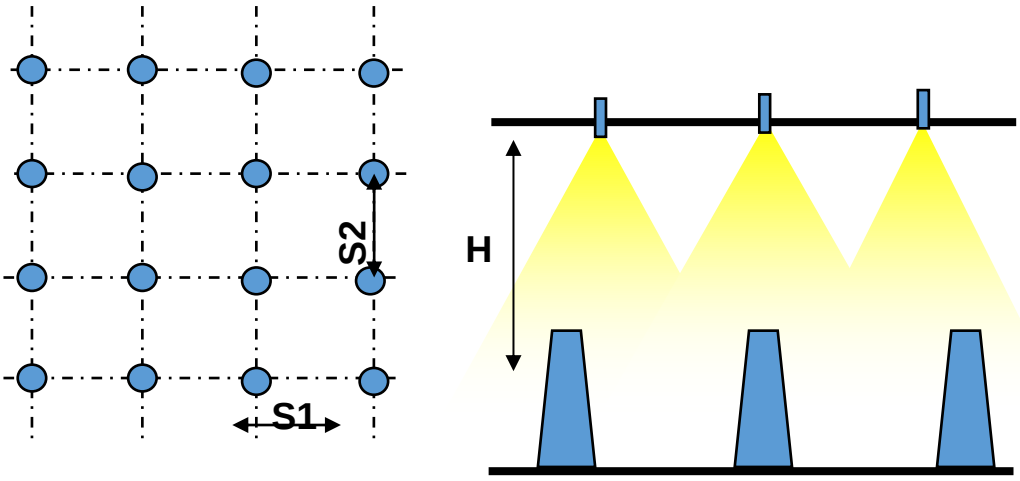


Fig. 13 Ambient Lighting Arrangement

5.2 Accent Lighting

Accent lighting is an important component in most merchandising lighting applications. Accent lighting enhances the appearance of products by highlighting their shape, texture, finish, and color. Point sources are well-suited for accent lighting because they offer precise control and direction, allowing for focused illumination. (*see* Fig. 14)

a) Accent lighting requires brightness higher than the surround. This means that the merchandise and displays shall be at least three times brighter than the surround.
b) To effectively capture attention, feature displays at the end of long aisles or showcasing jewellery often employ very high illuminance levels (sometimes as high as 15:1). However, in outdoor retail environments, it's essential to maintain brightness levels consistent with surrounding areas. Direct glare or reflections off merchandise should not obstruct motorist visibility or create nuisance glare.

For the horizontal display the luminaires are placed directly above the display area as shown in Fig. 14. This gives an even illumination of all the merchandise on display in the same horizontal plane. For the vertical display the luminaires are offset by some distance from the vertical plane of the display shelves. In general the offset distance should be about one-third of the average display height. That means the center line of the beam will be at around 30º from the vertical plane.

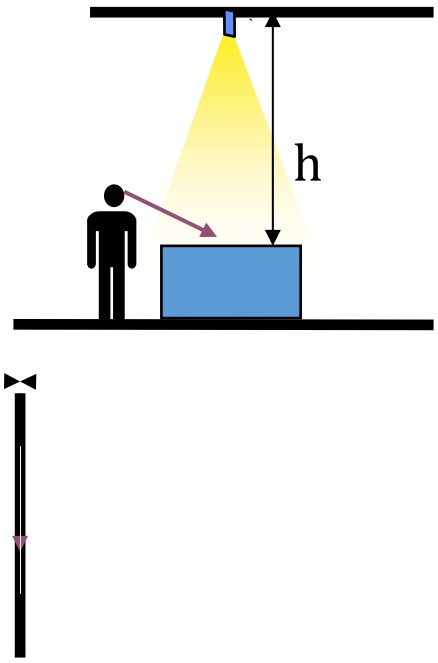
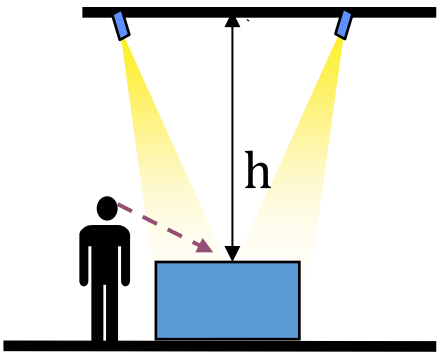


Fig. 14 Accent Lighting Application Images

For lighting a single, free-standing object or display, as shown in Fig. 15(a), good illumination in the horizontal plane is very important. This can best be provided by two accent luminaires or groups of luminaires offset by some distance from the vertical center line of the object. For even horizontal illumination, the beam widths should be selected so that the beam edges more or less meet at the middle of the object.

For lighting objects mounted on the walls, as shown in Fig. 15(b), the center of the luminaire beam – usually the part of the beam with the maximum luminous intensity – should reach the mid-to-top part of the display area. This is the part of the display which most naturally falls into the field of view of people at the intended viewing distance.



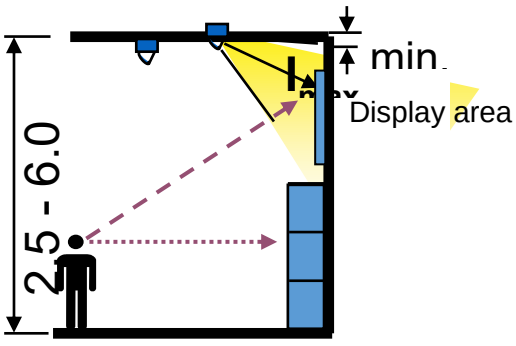


Fig. 15 (a) Optimal Lighting Techniques for Wall-Mounted Displays

Fig. 15 (b) Optimal Lighting Techniques for Single

5.3 Zoning

When general-purpose lighting varies across different areas of a room, it's referred to as zone-oriented lighting. Variations may include differences in brightness, angles of light incidence, types of luminaires, and light colors within the space. However, for zonal lighting to be effective, the quality of illumination within each zone must be consistent.

Common zones in a retail environment include entrances, cashpoints, circulation areas, feature displays, shelving, and wall areas. The ratio of general-purpose to accent lighting significantly impacts the overall lighting ambiance. Achieving the desired atmosphere depends on striking the right balance between these two lighting components.

Guidance on suitable ratios and lighting levels for various retail scenarios is offered by the Vertex philosophy, which is illustrated in a matrix diagram shown in Fig. 16.

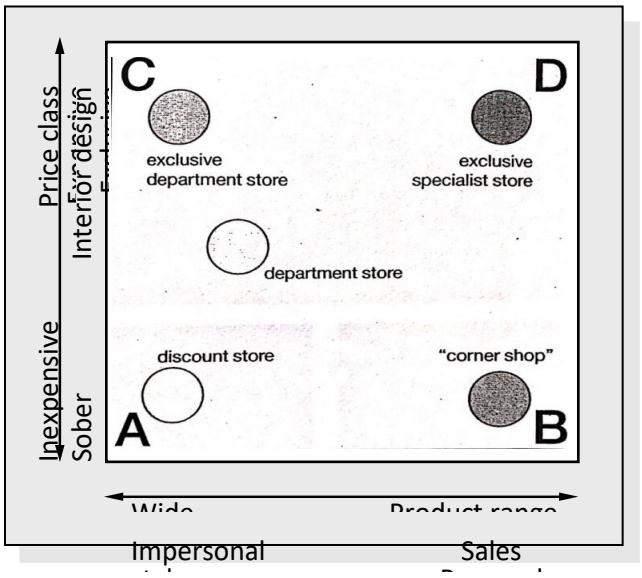


Fig. 16 Vertex Philosophy Matrix

The matrix categorizes the product range from wide to narrow and the sales atmosphere from impersonal to personal, in relation to the price category from inexpensive to expensive and the store furnishings from simple to exclusive. Taking the extreme retail situations at A, B, C and D as starting points, it is possible to identify the correct mix of general-purpose and accent lighting for any store.

A typical example of vertex A is the discount store, which presents a wide range of low-price merchandise in an impersonal, businesslike atmosphere. At 500 to 1000 lux, the high level of general-purpose lighting shows that this is a store offering goods at a very economy prices without sales assistance.

Vertex B symbolizes the "corner shop", where customers find a relatively narrow range of merchandise and are served by the owner of the store himself. The lighting level here is between 300 and 500 lux, appreciably lower than in a supermarket.

The higher the price category and the more exclusive the store, the greater the importance of accent lighting.

This complements general-purpose lighting by directing attention to quality brand articles in the diversified range of the exclusive department stores at vertex C. The trained sales personnel provide assistance only at the express request of the customer. The 300 to 500 lux general-purpose lighting required is assured by led luminaires. Accents emphasize the exclusive nature of the merchandise on display.

The product range at vertex D is of equal quality but narrower in scope. This exclusive specialist store places paramount importance on intensive sales assistance and advice. In this context, the lighting solution relies on accent lighting to create a stimulating effect, with greater contrast enhancing the impact. To further emphasize the accentuating light, general-purpose lighting is kept low at 300 lux.

5.4 Perimeter Lighting

Perimeter lighting is crucial for effectively illuminating a merchandising space, as the brightness of vertical surfaces significantly influences shoppers' perception of the store. It provides the lighting needed for merchandising walls and helps create a sense of spaciousness. When used correctly, perimeter lighting can entice potential customers from the main aisle into the merchandising area.

a) Perimeter wall lighting can be achieved by various techniques using either linear or point sources to create continuous or individual patterns of light.
b) Architectural cornices, soffits, or valances with concealed linear led strip-luminaires can be employed as well as properly spaced wall wash luminaires that provide a continuous luminous pattern
c) Patterns of light and concentrated accent lighting, which require precise beam control, can be achieved using track or monopoint luminaires, recessed adjustable luminaires, or widely spaced wall-wash luminaires.

5.5 Decorative Lighting

Decorative lighting elements include sconces, chandeliers, table and floor lamps, torchieres, light sculpture, and light art (graphics) as shown in Fig.17. Decorative lighting is used in the retail merchandise environment to create ambiance and set the mood for a shopping experience. It is used primarily in specialty stores, high-end department stores and designer boutiques. Decorative lighting must not compete or detract from the primary merchandise lighting scheme.

Fig. 17 Decorative Lighting Application Images

5.6 Feature and Display lighting

Inside the store, display lighting is used to highlight the desirable features of specific products, whether they are openly displayed or enclosed in showcases.

a) Regarding color, illuminating an object with strongly coloured light of the same hue deepens its colour, while strongly coloured light on the background and surroundings alters the overall atmosphere.
b) To achieve effective accent lighting in a display window, it's helpful to apply the principles of stage lighting, which include key light, fill light, and back light. Additionally, uplighting can be used to create a more dramatic effect as shown in Fig. 18.

Key Lighting **Up- Lighting** **Back- Lighting**

Fig. 18 Display Lighting

c) *Key light* — creates hard shadows and intense focus on the display. It highlights the main focus of attraction with the use narrow beam spotlights for key light.
d) *Fill light* — is soft light aimed from another direction to soften the shadows and give additional light from an area that has been excluded. Wide beam is the applicable optic for fill light.
e) *Back light* — is the lighting from behind to accentuate the size and shape of the display. Downlights or any wall -washer will work for back light.
f) *Up light* — is mostly use for heavy drama. It must be carefully used because it gives different effects on the display, which may lead to the wrong impression. Up light can create scary effect on the face of the mannequin.

Different materials require different display lighting techniques as listed in Table 5.

Table 5 Common Display Lighting Techniques for Particular Materials

(*Clause 5.6*)

Sl. No	**Materials**	**Display Lighting Techniques**
(1)	(2)	(3)
i)	Uniformly transparent materials	Transmitted light from a lit background; up-lighting possibly in colour
ii)	Glass and crystal	Highlighting; up-lighting possibly in combination with translucent background lighting; colored light
iii)	Precious stones and jewellery	Small spotlights, black velvet background
iv)	Opaque, shiny objects, e.g. silver	Spotlights, black velvet background, highlighting

v)	Opaque, textured objects	Light predominantly glancing across the surface
vi)	Transparent fibrous objects, e.g. fine textile	Contour lighting from behind

6 SUPERMARKETS

Supermarkets aim to create a relaxed ambiance for customers while shopping.

a) Meats, cheese, fruits, and vegetables benefit from LED technology because it emits very low levels of infrared (IR) and ultraviolet (UV) radiation at the light emission surface. This helps to protect the foodstuffs and packaging.

   Good lighting not only aids in orientation and enhances the shopping experience but also contributes to sales success. High-precision optical systems help direct light and attention to specific products, highlighting them effectively.

b) Lighting controls elevate supermarket lighting by allowing for the customization of lighting scenes in each area, enhancing displays. They also help conserve energy by adjusting light levels based on natural daylight availability. Smart controls with presence detection features can further optimize lighting by balancing light levels according to the volume of store traffic.

6.1 Fruit and Vegetable placement area

Optimum lighting not only ensures that merchandise is displayed effectively and helps to encourage people to buy, it also serves to highlight the individual trader's strengths on the shop floor. Systems with good colour rendering optimally emphasise the colour contrasts of products as shown in Fig. 19.

a) Crisp white light emphasizes the fresh green colour of vegetables.
b) Warmer light colors with red and orange aspects make fruits like apples and oranges look appealing.
c) Directional light with a strong contrast is also acceptable for illuminating vegetables. A low theatrical accent factor of 5:1 is generally considered.
d) Special optics and dedicated fresh food spectrum will create extra attraction and enhance the image of quality.

Fig. 19 Outstanding Colour Effects

6.2 Cheese, Bread and Pastries Placement Areas

Using lighting with white-yellow or red-brown tones for Cheese and Bread can make them look crisp and appetizing, enticing customers as shown in Fig. 20. For pastries, a cool white light can enhance the appearance of whipped cream, making it look fresh and inviting.

Fig. 20 Cheese, Bread and Pastries

6.3 Meat and Fish Areas

Shoppers use the visual appearance of meat to decide on its freshness and quality. It has been shown that warm white light with a subtle red glow displays the meat at its best. The sparkling white light makes the white fish look even shinier. Warmer colour temperature are used to enhance the natural appeal of Red Fish. (*see* Fig. 21)

Fig. 21 Meat And Fish Areas Lighting Placement Area Lighting

6.4 Freezers and coolers

Fresh products such as butter, milk, pre-packed meats, pastries, freshly made sandwiches, and fruit juices need to be displayed accessibly.

a) Concealed LED lighting for refrigeration cases is a greener, more energy efficient way to create an enjoyable shopping experience, improve product visibility and lower refrigeration costs. (*see* Fig. 22)

b) LED alternatives offer significant energy savings and have the added benefit of containing no mercury or lead, which helps reduce CO2 emissions. Optic systems that prevent the direct visibility of the light source and reduce glare while maintaining excellent light and colour consistency should be prioritized. This lighting solution should provide brighter and more

uniform illumination to enhance the colour and appeal of fresh goods. Additionally, implementing controls can further save energy and help guide shoppers to the freezer aisle.

Fig. 22 Freezers and Coolers Lighting

6.5 Cashier Area and Checkouts

Lighting should enable the personnel behind the pay counter to clearly see the pricing details. Customer should be able to check their bills and amount of money to be paid.

a) Luminaires should ensure optimum visual comfort, avoiding glare to the staff (*see* Fig. 23)
b) An accent factor of low theatrical 5:1 is generally preferred to illuminate the graphics uniformly.
c) Dimmable downlights can guide shoppers away from empty checkout desks when there are fewer staff in store to serve them. They can also be boosted to highlight promotional islands and encourage impulse purchases when there are queues at busy checkouts, adapt the lighting to suit the volume of traffic in store

Fig. 23 Cashier And Checkout Area Lighting

6.6 Grocery Aisles, promotional goods and shelves

Lighting should help customers to understand the layout of the shop and help them find the brand they are looking for.

a) General lighting needs to be at a high level of illumination with good levels in vertical plane to add sparkle to the products on the shelves without causing glare so they're also easy on the eye.
b) Light sources creating a neutral white color impression and giving a good color rendering should be used to enable quick product recognition.
c) When considering a trucking system, it's important to prioritize options that allow for spot placement every 60 cm, offer emergency lighting capabilities, and enable easy dimming through daylight harvesting or presence detection. A multifunctional trucking system can provide these features, offering a versatile lighting solution for various needs as shown in Fig. 24.
d) An accent factor of low theatrical 5:1 is generally preferred.
e) Lighting arrangement parallel to the racks is more efficient way to highlight the racks as the vertical levels are good. Merchandise is highlighted in a better way.

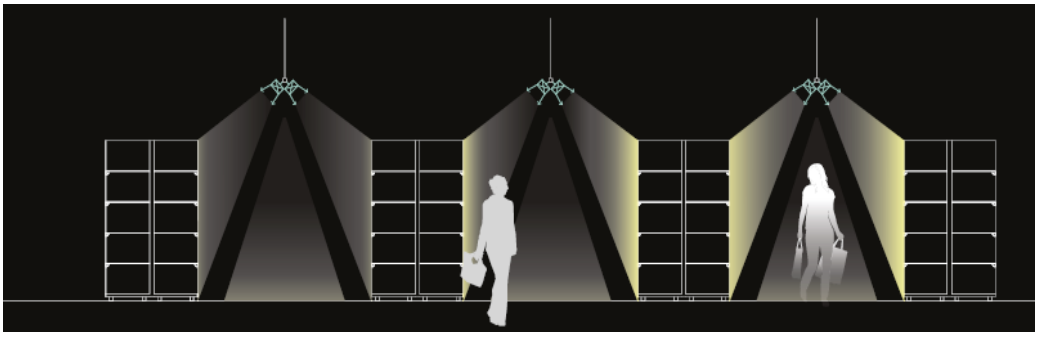


Fig. 24 Grocery Aisles, Promotional Goods and Shelves Lighting Arrangements: L to R – Tracks Illuminate From 20% To 100% As The Customer Approaches The Aisle Area

7 LIGHTING SYSTEM PARAMETERS AND TECHNIQUES

Lighting plays a crucial role in creating the right atmosphere, from the shop window and sales floor to the cash desk. To maintain consistent quality and appearance, it is essential to use a uniform luminaire system throughout the store.

When selecting a lighting system or a combination of systems, it's important to consider not only the architectural and interior design requirements but also the flexibility and adjustability needed for merchandising tasks.

7.1 Basic Approaches to the Lighting of Merchandise Areas in Stores

a) The general pattern lighting system utilizes a layout of luminaires to offer overall lighting throughout the sales area, with or without additional display lighting, and regardless of the merchandise's placement. This system may incorporate switching or dimming controls to provide flexibility in space utilization and to enhance energy efficiency.
b) The specific pattern system employs a layout of luminaires determined by the location of the merchandise displays (store fixtures, showcases, or gondolas). It is tailored to emphasize the merchandise and delineate sales areas.
c) The flexible pattern system includes a layout of electric outlets either continuous or individual designed for the temporary installation of luminaires. These outlets may be wired for multiple circuit application and control. This system can be used for general or specific pattern lighting and provides the flexibility to interchange luminaire types, allowing for customized lighting tailored to the merchandise display.

7.2 Three types of Lighting Equipment Frequently used in Flexible Pattern

a) Recessed adjustable luminaires, recessed adjustable pulldown luminaires and track lighting (*see* Fig. 25).
b) Recessed adjustable luminaires have the appearance of recessed downlights but provide aiming adjustability to between 30° and 45° from the vertical (depending on manufacturer) and usually 355° or more of horizontal rotation.

c) The most flexible system is track lighting where the luminaire can be positioned at any point on a linear electrified track of arbitrary length, and the luminaire is adjustable both horizontally (355°) and vertically (0 to 90°).
d) Track lighting can sometimes give the appearance of clutter on the ceiling. While pulldown and track luminaires offer great flexibility, it's important to be cautious with their use to avoid creating glare from the aiming angles.

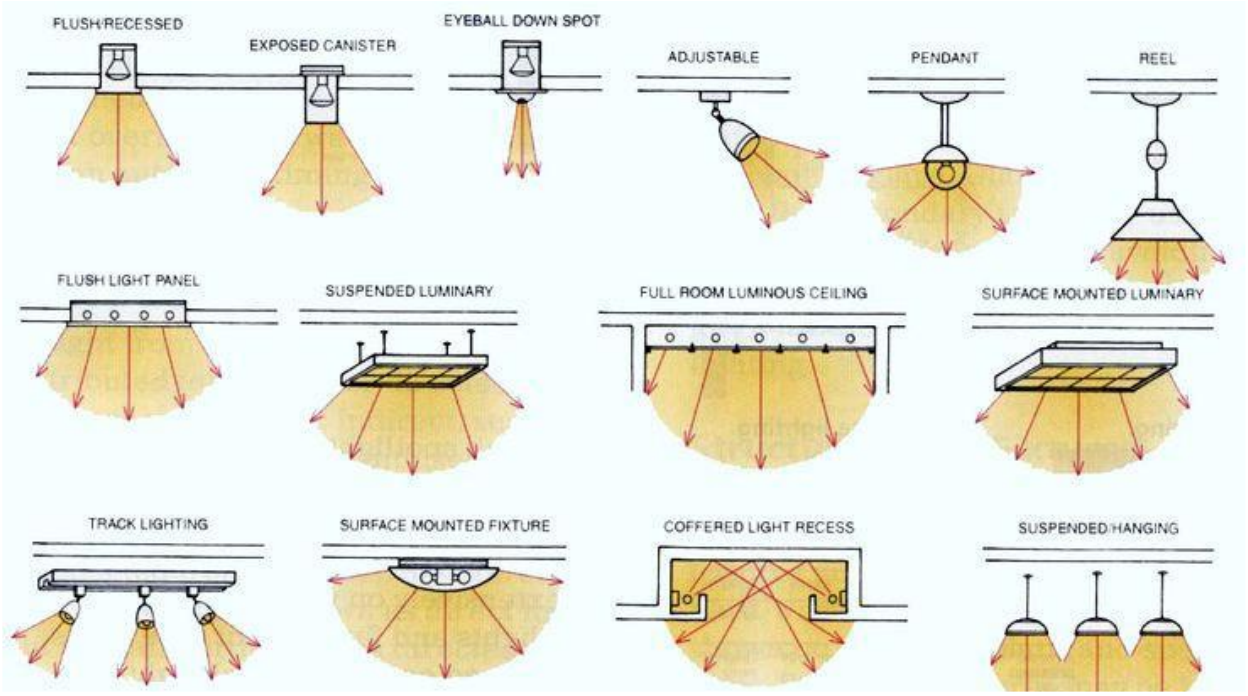


Fig. 25 Examples of Type of Retail Lighting Equipment

7.3 Common types of Luminaires used in the Retail Shops

a) Track Lights
b) Downlights
c) Wall Washers
d) Shelf Lights
e) Pendant Lights
f) Cove Lights
g) Back Lit
h) Decorative Lights

7.3.1 *Track Lights* — Track lights can be mounted recessed surface or suspended. This is the most flexible type of luminaire in retail shops. Gondolas and shelves are sometimes moved from one place

to another and using track lighting is the best solution for these changes. Track lights can not only be aimed flexibly, they are also easy to install and maintain.

Beam optics play a vital role in track lights. The narrow beam and wide beam (or some manufacturers call it spot and flood beam) can be used according to its purpose as shown in Fig. 26. Flood beam can be used for general lighting or for wide areas to be highlighted, while spot beam can be used to focus one item and highlight it deliberately as shown in Fig. 27.

The first rule of using track lights is to focus the beam onto the merchandise from the viewer's point of view. Improper use of track lights may cause glare.

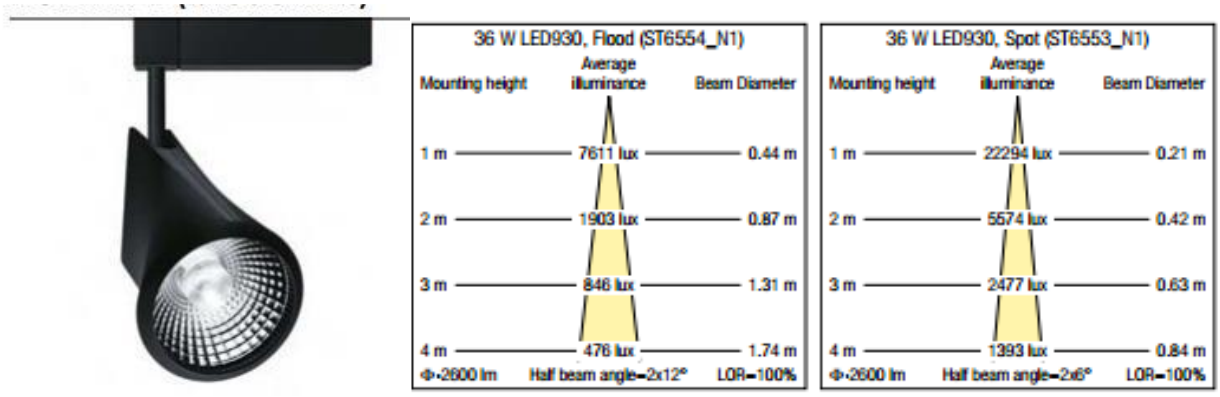
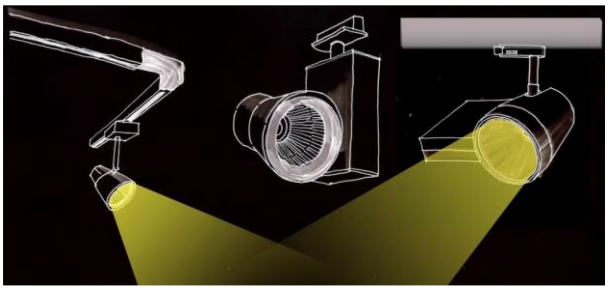


Fig. 26 Use Narrow Beam Spotlights For Key Light to Create Hard Shadows And Intense Focus On The Display



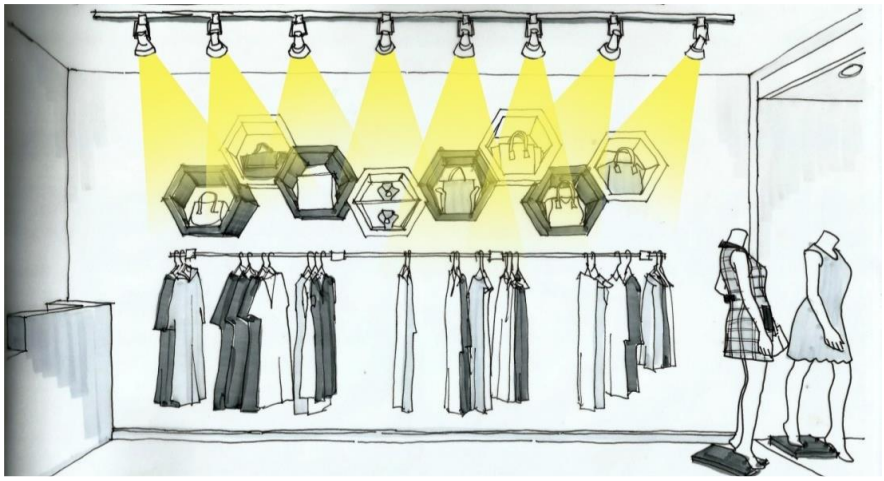


Fig. 27 Track Lights to Highlight The Merchandise

7.3.2 *Downlights* — Adjustable downlights are not that flexible, but they are doable. They may not work in high ceiling rooms. But the main advantage of adjustable downlights is the clean arrangement in the ceiling. Downlights can be mounted in the ceiling as well as inside shelving as shown in Fig. 28. They can be single, twin/double or triple gimbals that can be aimed in different directions. The option of spot and flood beam is also available for these adjustable and fixed downlights.

Fig. 28 Adjustable Downlights Effect

7.3.3 *Wall Washers* **—** Wall Washers are the best solution for vertical illuminance. Having a bright wall will make the retail shop seem wider and bigger. Wall Washers can be downlights, linear lights or cove lights as shown in Fig. 29.

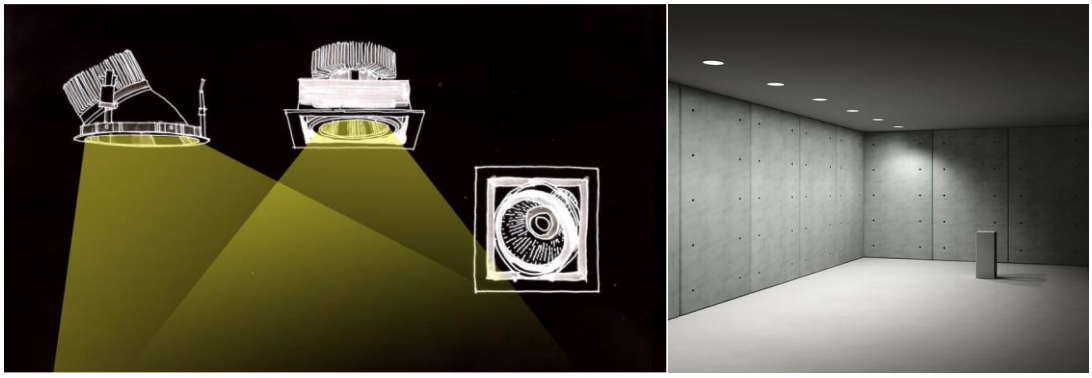


Fig. 29 Wall Washing

To get a uniform effect, the distance of the luminaire from the wall is properly analyzed. There may be a hindrance with the spacing, but it is very important to solve it during the design stage, otherwise the wall washing will look annoying because the customer's eye will mostly be directed to the vertical light not to the horizontal.

7.3.4 *Shelf Lights* **—** Shelf lights are usually integrated into shelves as shown in Fig. 30. They are used to highlight the merchandise closely. The most common shelf lights are strip LEDs or small pin lights.

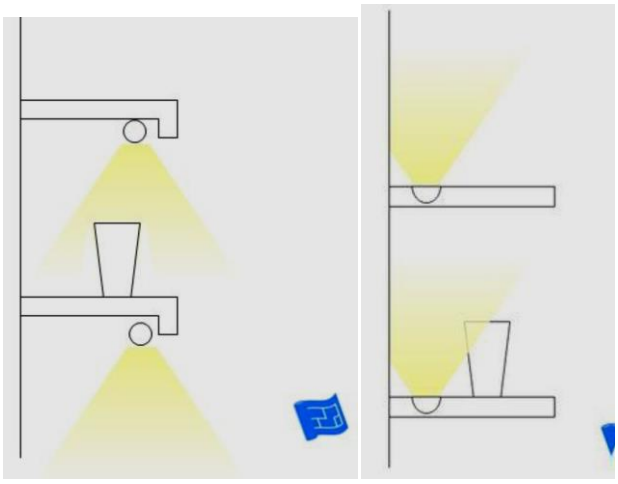


Fig. 30 Shelf Lights Integrated Within the Furniture

7.3.5 *Pendant Lights* **—** Pendant lights can be used for general lighting or functional lighting as shown in Fig. 31. High ceiling retail shops prefer to use industrial design suspended luminaires. Open ceiling retail shops prefer to use them as well.

Fig. 31 Pendant Light Application Image In A High End Retail Store

7.3.6 *Cove Lights* **—** Cove lights create soft illumination. This not only helps the general lighting level, but also it produces a different effect on emotions by highlighting the edges of the space.

Cove lights can be installed in ceilings, walls or shelves as shown in Fig. 32. An example of Cove light effect is depicted in Fig. 33. The most common lamps used in cove lighting are LEDs. The installation varies depending on the cove design.

Due to the efficiency of LEDs, these are now widely used for cove lighting. They also lessen the maintenance aspect because of their long life.

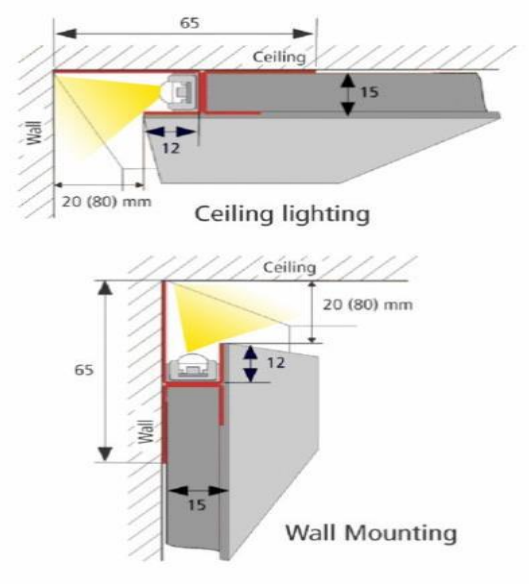


Fig. 32 Cove Light Ceiling Detail **Fig. 33 Cove Light Effect**

7.3.7 *Back Lit* — Back lit is used to enhance the overall ambience of the retail shop. It gives uniform effect and it widens the appearance of the room as shown in Fig. 34.

In working the lighting design, the spacing and the distance of the LED to the panel must also be checked to ensure the visibility of LED light dots.

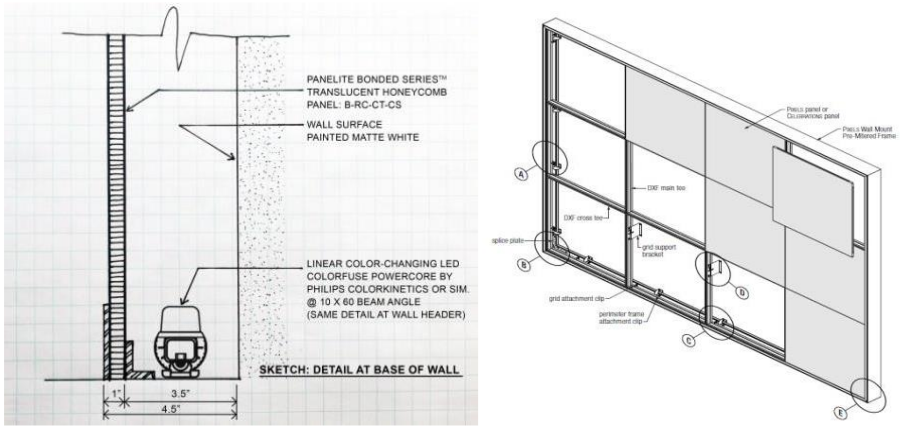


Fig. 34 Back-Lighting Panel Detail

8 LED ADVANCEMENTS IN RETAIL

Fig. 35 Multifunctional Lighting Setup For Background Illumination And Mannequin Accentuation With Controllable Leds For Dynamic Foliage Effect

The lighting setup comprises two separate tracks (*see* Fig. 35) for illuminating the background with colored light (yellow symbol) and highlighting mannequin dolls with white light (pink symbol). Additionally, small, individually controllable LEDs (pale pink symbol) are strategically positioned at the bottom of the background board within a groove. These LEDs can be adjusted to change intensity, creating a dynamic effect that simulates foliage moving in the wind.

Furthermore, LED lighting fixtures can be connected and enhanced with sensing, transmission and communication capabilities integrated with the latest technology.

a) Retailers have the opportunity to connect with shoppers through data-enabled LED lighting systems that can collect and send relevant information using wireless communications, specially designed mobile apps, and icloud services, letting them create innovative, interactive experiences in store.
b) In combination with a retailer's app, LED technology makes it possible for a smartphone to know its location in store. The app can provide information of where to find a product, showing a map with an indication of the shopper's location and the product location.
c) It is also possible to show promotions based on the shopper's location or more information about a specific product kept close.
d) Businesses could help warehouse staff work more efficiently with easier product finding and location-based stocking instructions enabling more efficient and effective store operations.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 7 Lighting for Art & Museum

[First Revision of SP 72 (Part 5/Section 7)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49	**Last Date for Comments: 06-June-2024**

FOREWORD

The word “Art” itself means and demands a boundary less mindset for free flow creativity. Similarly, the subject of “Light for Art” demands flexible approach in conjunction with appropriate lighting tools and design principles. This section of code should be viewed as guideline and recommendation from good lighting practices applied for Lighting of Art.

1 SCOPE

This section covers various aspect of appropriate lighting for Art with detailed reasoning through illustrations of positive effects with right approach.

2. TERMINOLOGY

The definitions of the terms used in this section are given in Part 1 of this code.

3. NORMATIVE REFERENCES

Other Standards	*Title*
CIE 157: 2004	Control of damage to museum objects by optical radiation

4. UNDERSTANDING THE WORLD OF ART

Let's begin with understanding the world of Art before exploring the subject of "Light for Art"

4.1 Entities: Art Museum and Art Gallery

The art world involves two different types of entities: art museum and art gallery.

As an establishment, art gallery refers to a place that exhibits and sells artwork of different artists. On the other hand, the word museum has the meaning of 'a place where artifacts are stored.'

4.2 Type of Art

The form/shape of most common type of artwork is 2D (Two Dimensional) on wall paintings and 3D (Three Dimensional) in cabinet/on pedestal/on floor (sculptures). However, there are museum with artifacts displayed other way round or both.

5. ROLE OF LIGHTING IN THE WORLD OF ART

The role of lighting is extremely critical in the world of art. Key roles that lighting plays are as follows:

a) The contribution of lighting begins even before you enter the museum building. While the front lighting of museum building establishes City's cultural landmarks, exterior lighting creates striking night time signals for urban and guides visitors into the museum using pathway lighting.
b) In common traffic zones such as entrance foyers, halls or connecting pathways, lighting can be particularly effective in facilitating orientation and drawing attention towards important information, objects or elements.
c) In the exhibition rooms, lighting either establishes impartial attention with uniform brightness levels or creates visual hierarchy by high contrast which sets off central items in the collection from their spatial context and emphasises their special significance.
d) In extended part of large museums, such as the bookshop and café, lighting creates attractive and pleasant atmosphere for visitors.
e) In case of mains power failure, emergency lighting provides safe exit from the building
f) Outdoor Area lighting provides for overall security of the Museums premise

6. LIGHTING APPLICATION CRITERIA

6.1 Transition from Outdoor to Indoor

The first and foremost consideration is the transition from bright outdoor in daytime to indoor space. Entrance foyer zone should be illuminated brightly to ensure smooth transition for visitors entering the museum.

6.2 Lighting for pictures 2D (Two Dimensional)

There are broadly two approaches to illuminate Two Dimensional artworks:

6.2.1 *Uniform Lighting*

One approach to illuminate 2D (Two Dimensional) artwork is by applying uniform brightness towards entire wall surface area. This can be achieved by "wallwashing" or by "direct/indirect diffused" lighting as illustrated in Fig. 1, Fig.1 (a), Fig. (b) and Fig. 1(c).

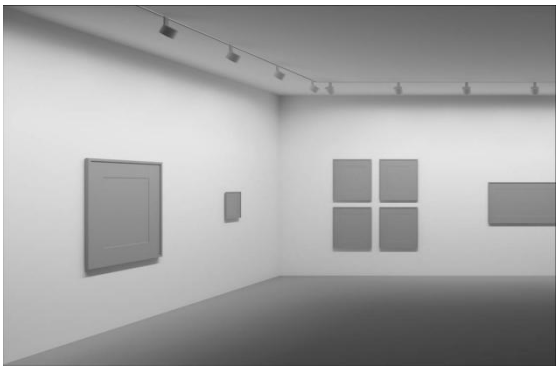


Fig. 1 Wallwashing

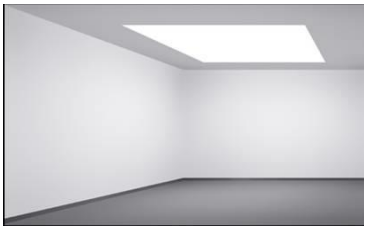


Fig. 1(a)

Direct Diffused Lighting
(Natural or artificial)

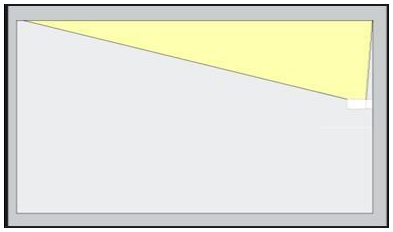


Fig. 1(b)

Indirect Diffused
(Ceiling washlight)

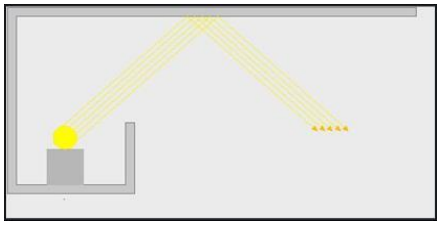


Fig. 1(c)

Indirect Diffused
(Wall/Ceiling Cove)

Some of the advantages with uniform vertical illumination are:

a) The uniform illumination of vertical room surfaces gives artwork prominence similar to the room and creates a homogenous appearance.
b) Uniform wallwashing provides a neutral backdrop for exhibitions and presents artwork on the walls in an objective manner. It is suitable particularly where the mood to be induced for viewing artwork is to be contemplative rather than dramatic.
c) Uniform illumination of vertical surfaces gives the impression of a bright and spacious room, with even brightness levels creating a harmonious atmosphere in which pictures and wall form an integrated whole.
d) Large art works covering entire wall surface can be well lit
e) Luminaires do not need to be readjusted or relocated for change in picture size or position.

However, some Artist / Curator consider uniform lighting approach as dilution of attention towards their exhibits.

6.2.2 *Accent Lighting*

The alternate approach to illuminate 2D (Two Dimensional) Artwork is “Accent lighting” to establish visual hierarchy through high contrast as illustrated in Fig. 2.

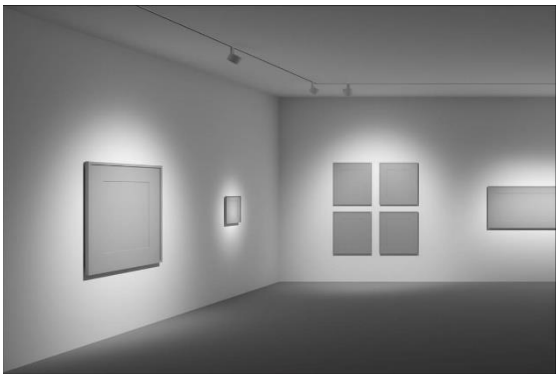


Fig. 2 Accent Lighting

Some of the advantages with Accent lighting:

a) Creates dramatic atmosphere rich in contrast
b) Directs the view of the visitors to concentrate on the artwork
c) Directed Accent light results in brilliance and good modelling
d) Ensures the rest of the interior and the architecture play secondary role
e) Establishes hierarchies of perception to give structure to the exhibition

To achieve good accent lighting, it is very important to consider following criteria’s:

6.2.2.1 *Angle of incidence*

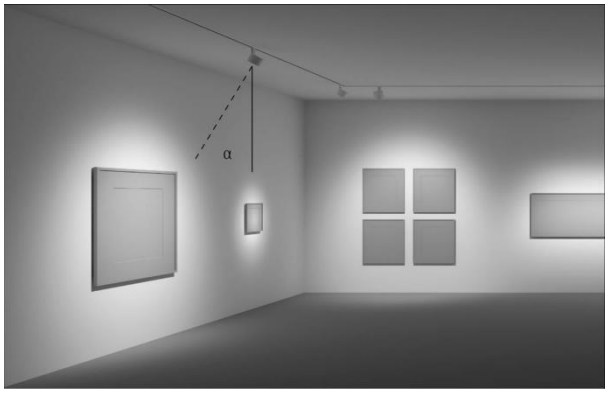


Fig. 3 Angle of Incidence

For optimum result, the recommended angle of incidence is 30°, as illustrated in Fig. 3

30° angle of incidence (Ideal & Desirable) as illustrated in Fig. 4

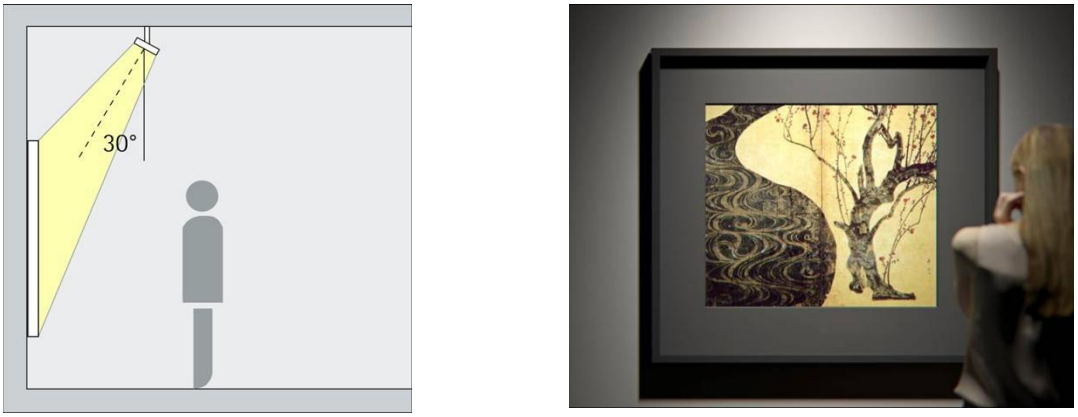


Fig. 4 Angle of Incidence (Ideal & Desirable)

a) Ideal museum angle
b) No glare
c) Good modelling
d) Uniform impression of brightness

Below images explains negative consequences otherwise with regards to angle of incidence:

If Angle of incidence <30°, as illustrated in Fig. 5

Fig. 5 Angle of Incidence <30°

a) Disturbing hard shadowing
b) Exaggerated structural details
c) Low impression of brightness despite high illuminance levels

If Angle of incidence >30° as illustrated in Fig. 6

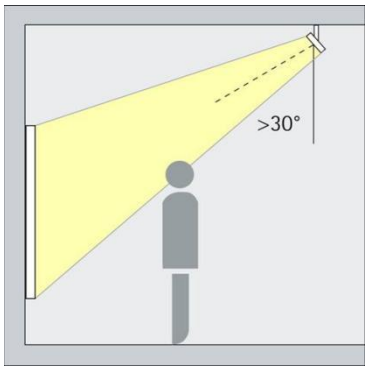


Fig. 6 Angle of Incidence>30°

a) Danger of shadows from the observer
b) Danger of reflected glare
c) Low modelling

6.2.2.2 *Beam diameter of incident light*

Below Fig. 7 shows the beam diameter of incident light

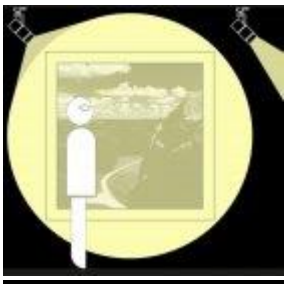


Fig. 7 Beam Diameter of Incident Light

For equal justice to every part artwork, the beam diameter of incident light should ideally be covering entire art work as illustrated in Fig. 8

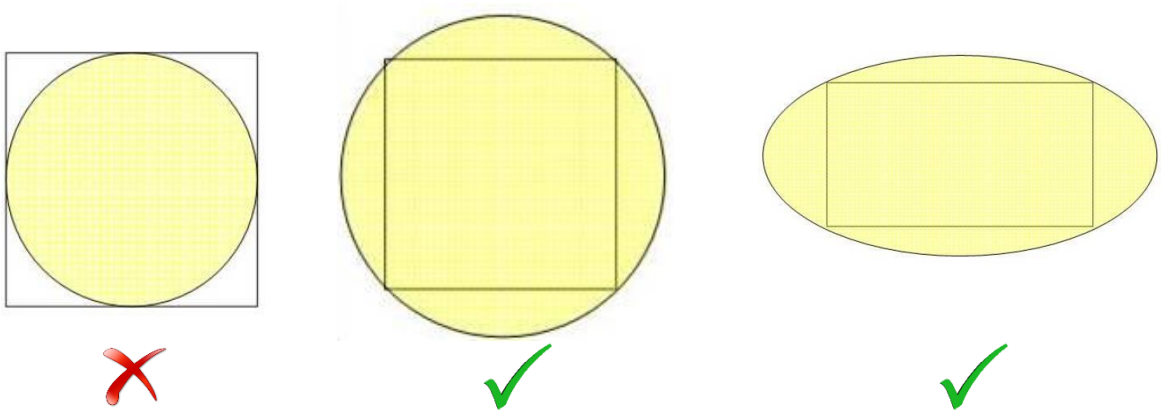


Fig. 8 Illustration

Black Square/Rectangle = Artwork

Yellow Circle/Oval = Light Beam

Alternatively, for extreme dramatic accent lighting, you can consider framing projection where the light beams are adjusted & restricted to size of painting. With this option, paintings appear to be self illuminating resulting in concentrated and mysterious atmosphere as illustrated in Fig. 9.

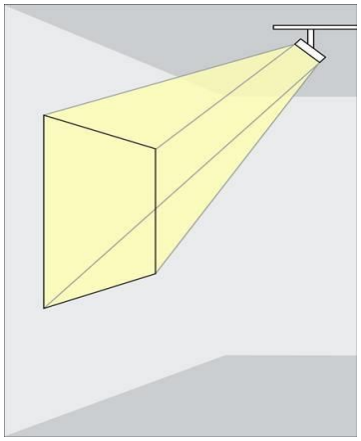


Fig. 9 Illustration

6.3 Lighting for Sculptures (3D)

The approach to illuminate three dimensional Sculpture is also similar to 2D (Two Dimensional) pictures usually “Accent lighting” with luminaire mounted on ceiling or floor.

6.3.1 *Uniform Lighting*

One approach to illuminate 3D (Three Dimensional) artwork is by applying uniform brightness towards entire sculpture with “diffused” lighting as illustrated in Fig. 10.

Fig. 10 Diffused Lighting (Natural or Artificial)

Some of the advantages with uniform diffused illumination are:

a) The Diffused light creates calm and homogenous atmosphere
b) The No shadows or soft shadows create a peaceful impression
c) It is suitable particularly where the mood to be induced for viewing artwork is to be contemplative rather than dramatic.
d) Gives exhibits an objective appearance.
e) Luminaires do not need to be readjusted or relocated for change in Sculpture size or position.

However, the diffused or uniform lighting reduces or eliminates the depth, structural details and three dimensionality due to lack of shadow. Hence, many Artist/Curator do not prefer this approach of uniform diffused lighting.

6.3.2 *Accent Lighting*

The alternate approach to illuminate 3D (Three Dimensional) Artwork is “Accent lighting” to establish high contrast with luminaire mounted on ceiling or floor as illustrated in Fig. 11.

Fig. 11 Accent Lighting

Some of the advantages with Accent lighting:

a) Creates dramatic atmosphere rich in contrast
b) Directs the view of the visitors to concentrate on the artwork
c) Directed Accent light results in brilliance and good modelling
d) Ensures the rest of the interior and the architecture play secondary role.
e) Establishes hierarchies of perception to give structure to the exhibition.

To achieve good accent lighting, it is very imperative to consider following guidelines:

6.3.2.1 *Angle of incidence*

Below Fig.12 shows the angle of incidence

Fig. 12 Angle of Incidence

For optimum result, the recommended angle of incidence is 30°.

30° angle of incidence (Ideal & Desirable) as illustrated in Fig.13

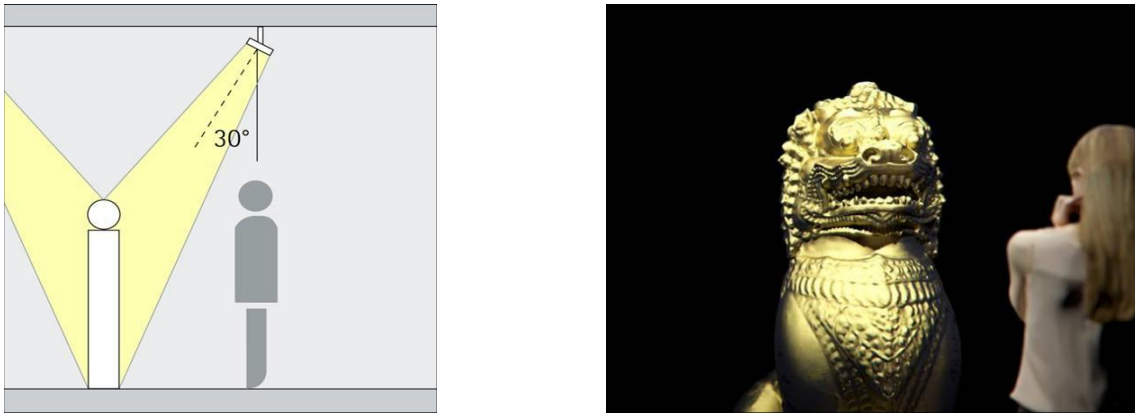


Fig. 13 30° Angle of Incidence (Ideal & Desirable)

a) Ideal museum angle
b) No glare
c) Good modelling
d) Uniform impression of brightness

If Angle of incidence <30° as illustrated in Fig. 14

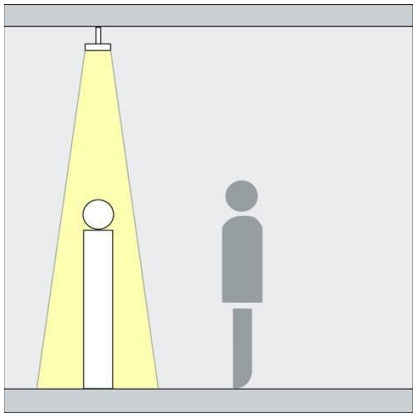
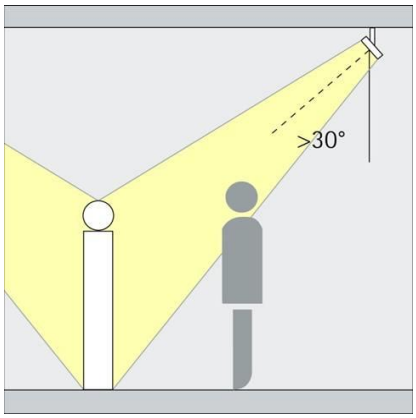


Fig. 14 Angle of Incidence <30°

a) Strong shadowing
b) Exaggerated structural details
c) Low vertical illumination

If Angle of incidence >30° as illustrated in Fig.15



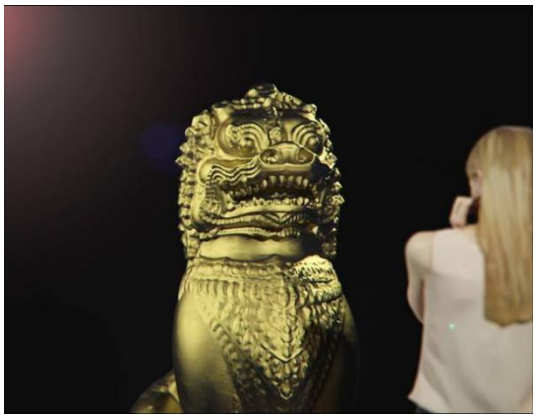


Fig. 15 Angle of Incidence >30°

a) Danger of shadows from the observer
b) Danger of direct glare
c) Low modelling

6.3.2.2 – *Spacing between fixture for sculpture*

Below Fig. 16 shows the spacing between fixture for sculpture

Fig. 16 Spacing Between Fixture for Sculpture

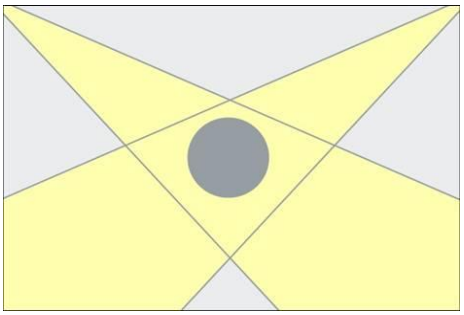
For optimum result, the recommended spacing is 120 degree i.e β =120 Degree.

One fixture should be positioned at backside centre point and 2 fixtures from either sides.

This recommendation is for sculpture with primary view from front but will also be viewed from all sides. Please note that 3 fixtures/beams will cast 3 shadows on floor.

In situation with only front view, 2 fixtures from side at 120 degree spacing is good enough.

Please refer illustration of Fig. 17 as below:



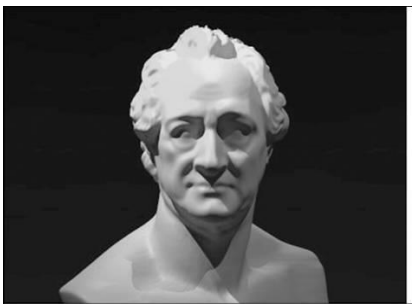


Fig. 17 Illustration

On case to case basis some artist may also prefer to use single directed light as illustrated in Fig.18

Fig. 18 Single Directed Light

6.4 Showcase Lighting

In case of 2D (Two Dimensional) Art (open book, ancient scripture etc) and 3D (Three Dimensional) (Miniature objects) exhibited in an enclosed transparent glass showcase, the lighting of the same can be done different ways. This is mainly to allow visitors enjoy a close up all round view without risk of theft and environmental or human touch damage.

There are broadly two methods to illuminate exhibits inside showcase as explained below:

6.4.1 – *Luminaire Positioned Outside the Showcase*

In this method, the luminaires are placed outside the display unit, preferably on top to avoid shadows of visitors on the exhibit. This will also avoid reflections from glass to the observer field of vision. This method is highly recommended for exhibit with sensitive material as the heat from luminaires is away from exhibit and outside the showcase as illustrated in Fig. 19.

Fig. 19 Luminaire Positioned Outside the Showcase

6.4.2 *Luminaire Positioned Inside the Showcase*

With this method, miniature spotlight or fibre optic based spotlight are mounted inside the display case for accent lighting. Alternatively, diffuser based LED strip can be used from multiple sides of Display case frame for uniform lighting over the exhibit.

This method is recommended when external mounting is not possible and exhibit is made of sensitive material. With luminaires placed inside the showcase, there is no chance of observers shadow on the object.

> **Note—**To minimise glare/reflection from glass surface, it is important to maintain low level of ambient lighting in the area where exhibits are displayed in Glass cabinet.

7. CONSERVATION COMPLIANT LIGHTING

Conserving artwork is one the most critical subject in the world of art. Apart from protection from physical or mechanical damage, artwork also gets damaged by exposure to light during public viewing and exhibition. Hence, it is very important to ensure that lighting solution and tools are Conservation compliant. Below is the brief on various considerations for the same.

7.1 – Damage Factor

A low damage light spectrum is the prerequisite for conservation compliant lighting.

a) Light is only one component of the electromagnetic spectrum (380nm = blue to 780nm = red)
b) > 780nm infrared radiation (= heat)
c) < 380nm UV radiation

Halogen spectrum is illustrated in Fig. 20

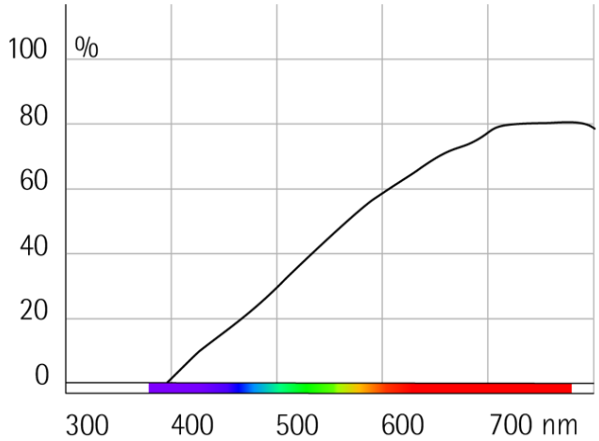


Fig. 20 Halogen Spectrum

Impact of light radiation is illustrated in Fig. 21

UV radiation:

-weathering
-chalking

Light:

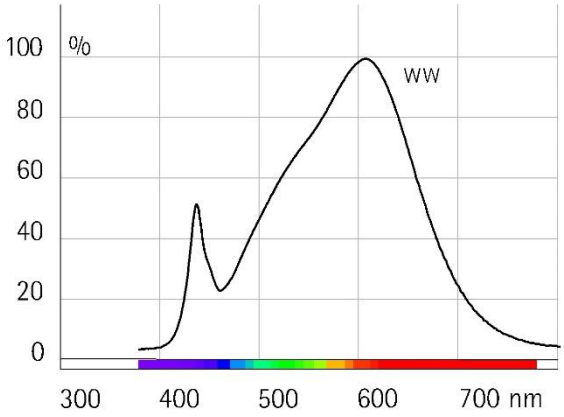
-fading

IR radiation:

-chemical, biological or mechanical decay

Fig. 21 Impact of Light Radiation

The typical spectrum of high quality 3000K LED shown below in Fig. 22



Light:

Fig. 22 Typical Spectrum of High Quality 3000k LED

a) LED spectrum: components in the UV and IR range hardly exists
b) The damage to exhibit from UV & IR is negligible from high quality LED source
c) There is still damage caused by Light spectrum (380nm blue to 780nm red)

7.2 Ways to limit Damage caused by illumination

7.2.1 *Use Light Sources With Low Damage Factors.*

Damage potential can be measured for each light source spectrum as illustrated in Fig. 23

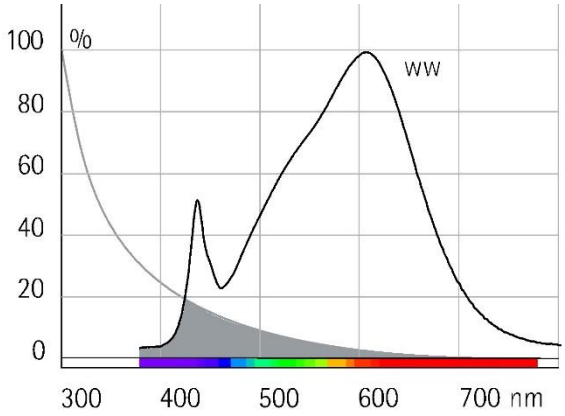


Fig. 23 Relative Spectral Sensitivity of Museum Typical Materials

(b= 0.12 acc. To CIE 157: 2004)

a) Short wavelengths have higher damage potential
b) Low spectral components in the shortwave range achieve lower values
c) Relative damage factor = flat rate value for museum typical materials
d) LEDs with warm white light colour have the lowest value

The relative damage factor is tabulated below in Table 1 & Table 2 for typical high quality LED source:

Table 1 Relative Damage Factor for Typical High Quality LED Source

(*Clause* 7.2.1)

Sl.No	**Light Source**	**Relative Damage Factor F (Mw/Lm)**
(1)	(2)	(3)
i.	LED 2700K, CRI 92	0.151
ii.	LED 3000K, CRI 92	0.165
iii.	LED 3000K, CRI 95	0.160
iv.	LED 3500K, CRI 92	0.170
v.	LED 4000K, CRI 82	0.190
vi.	LED 4000K, CRI 92	0.198X

Table 2 Relative Damage Factor of Other Light Sources:

(*Clause* 7.2.1)

Sl.No	**Light source**	**Relative damage factor f (mW/lm)**
(1)	**(2)**	**(3)**
i.	QT-12 RE with UV	0.159
ii.	Filter	0.169
iii.	QT-12 RE HIT 930	0.182

7.2.2 *Other Parameter Causing Damage to the Exhibit*

Apart from damage factor of light source, the other two parameters that causes damage to the exhibits are:

a) Lighting level
b) Exposure (Duration of lighting level)

Energy quantity by exposure (luxh) = illuminance (lux) x duration (hr)

This exposure damage is independent of whether the exhibit is continuously exposed to light or with interruptions.

a) Less light will have less damage
b) But lower the light, lower the visual acuity (clarity of vision)
c) From a conservation viewpoint, not the lighting level (lux) but exposure is decisive.

Hence, it is important to determine material categories based on their spectral sensitivity and exposure as below:

7.2.2.1 Individually determine the spectral sensitivity of objects in a collection or subdivide into material categories (in accordance with CIE 157:2004) as illustrated in Fig. 24

1) Insensitive	2) Low sensitivity	3) Medium sensitivity	4) High sensitivity

Fig.24 Material Category

7.2.2.2 Assign acceptable level of exposure (acc. to CIE 157:2004) as illustrated in Fig. 25

Therefore control the conservation of the exhibits (usually up to a just perceptible colour change)

1) No limitations	2) 200lux at 600,000luxh/a	3) 50lux at 150,000luxh/a	4) 50lux at 15,000luxh/a

Fig. 25 Acceptable level of Exposure

a) For Insensitive material exhibits, there is no defined limitation and can be exposed to required illumination without limitation of lighting level or daylight
b) For low sensitive material exhibits, the level of exposure to be maximum 200lux at 600,000luxh/a (Lux hours per annum) with controlled daylight contribution
c) For medium sensitive material exhibit, the level of exposure to be maximum 50 lux at 150,000 luxh/a (Lux hours per annum) with no daylight
d) For medium sensitive material exhibit, the level of exposure to be maximum 50 lux at 15,000 luxh/a (Lux hours per annum) with no daylight

The recommended lighting level of 50 lux for Medium to High sensitive material exhibits is is with below considerations:

a) No ambient light with dark room finish.
b) 50lux for a person in the mid 20's.
c) Adapted eye i.e visitor is arriving in conservation zone from previous zone lit with 200 lux and not from higher lux levels zone like reception or daytime outdoor zone)
d) Exhibits with bright colour tones
e) Exhibit with low details and less complex structures

Higher lighting level above 50 lux may be considered in consultation with conservator for older age visitors or exhibit with Darker & rich detail.

7.2.2.3 Classification of type of lighting is illustrated in Fig. 26

Lighting classes help to design and plan physical and visual connections in an exhibition

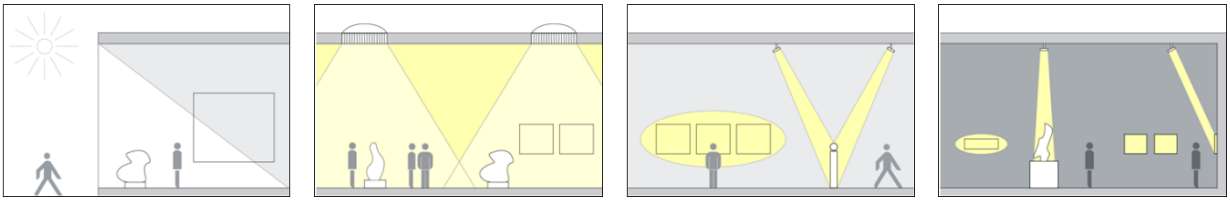


Fig. 26 Type of Lighting

8. LIGHTING TOOL SELECTION CRITERIA

Lighting Design application alone is not sufficient to achieve optimum desired results. It is achieved with good quality light source and appropriate fixtures.

8.1 Criteria for selecting LED Light Source

Apart from low damage factor of light source discussed in **7.1**, some other important criteria for consideration are:

8.1.1 *C R I*

Below Fig. 27 is the current methods or benchmark for evaluating CRI (Ra) of light source

Fig. 27 Current Methods or Benchmark for Evaluating CRI of Light Source

a) Evaluates the colour fidelity (Ra)
b) 8 test colours (pastel tones)
c) Based on standards

The recommended CRI value for selected LED source is > 90 with least damage factor (Please refer values shared in **7.2.1**)

TM-30

Fig. 28 shows LED color rendering:

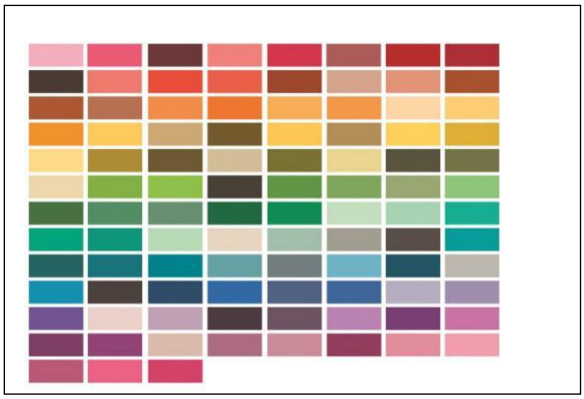


Fig. 28 LED Color Rendering

a) Evaluates the colour fidelity (Rf) and saturation (Rg)
b) 99 test colours (pastel tones and saturated colours)

The Colour rendering indices are comparison between test light source and reference spectrum. However, its not a measure for performance of human colour perception. Higher colour rendering index does not automatically mean good colour rendering and hence Visual sampling and evaluation is always recommended.

8.2 Critical Criteria for Light Fixture Selection

The demand for flexibility due to very nature of continuous change in display of exhibition and its location, tarck mounted spotlights are most suitable for Museum/Gallery. Track mounted spotlight is illustrated in Fig. 29

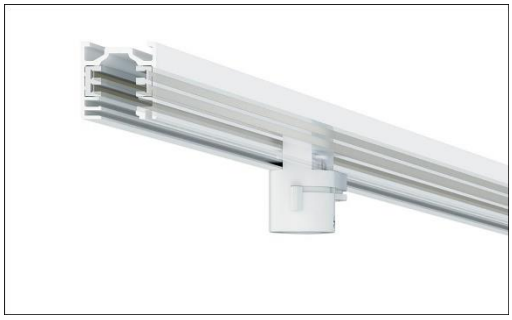


Fig. 29 Track Mounted Spotlight

Some of the critical criteria for selection of light fixture are as below:

8.2.1 *Maximum Beam Options*

Below Fig. 30 shows beam options

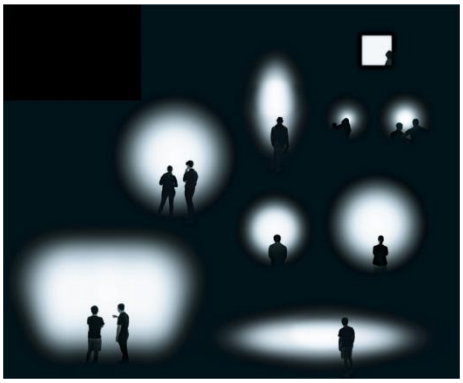


Fig. 30 Beam Options

The composition of various size and shape of different art exhibits makes it imperative for lighting tool to offer maximum possible beam angle without compromising the efficiency as shown in Fig. 31.

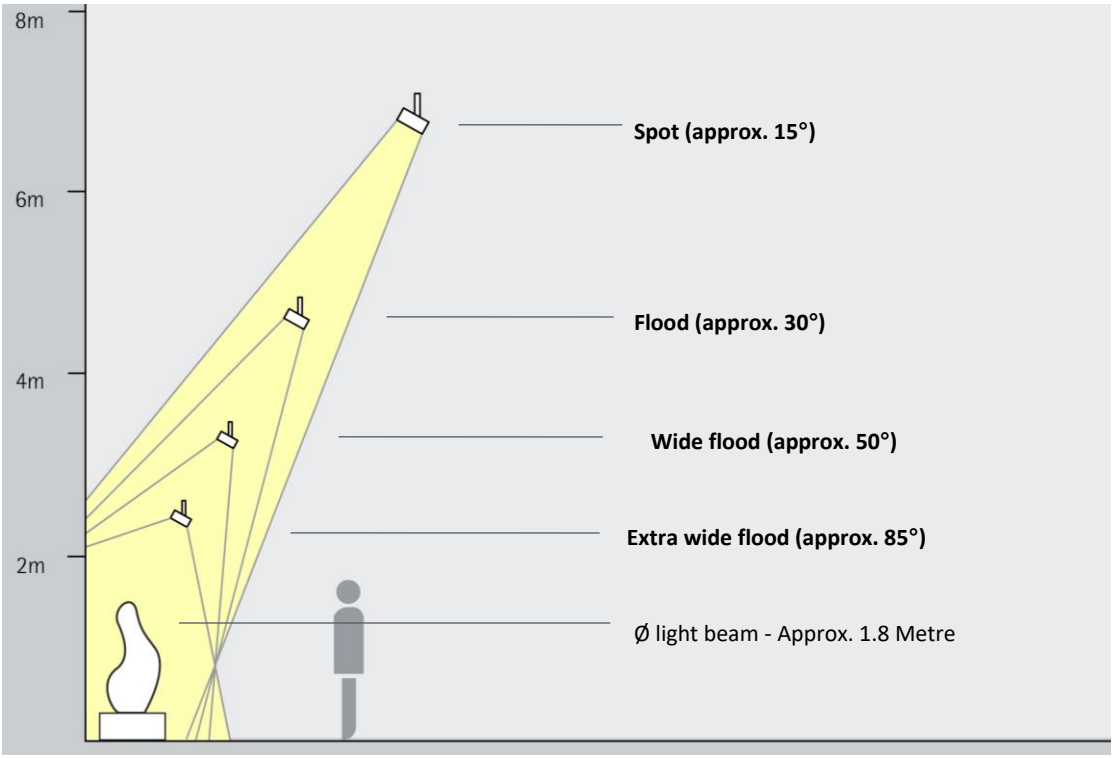


Fig. 31 Decrease in Beam Angle with Increase in Mounting Height

The above representative image illustrates “decrease in beam angle with increase in mounting height” to maintain same beam diameter. However, the “required wattage/delivered lumens will increase with increase in height” to maintain same lux level on object.

8.2.2 *Glare Control*

Good Lighting design is one aspect to enhance the quality of the exhibition experience; another is the level of visual comfort of the lighting. Precise beams of light with minimum spill light beyond primary beam and appropriate luminaire positioning minimises direct and indirect/reflected glare for the visitors. Please refer section 6.2.21 (For 2D objects) and 6.3.2.1 (For 3D objects) for ideal incident angle (30 degrees) to avoid direct/reflected glare.

8.2.3 *Flicker Free Visual Environment*

Flicker can be distinguished broadly as one which is visible to human eye and another through camera devices. The light fixture with poor quality control gear may result in flicker, especially in dimmed down scene setting. It is recommended to evaluate fixtures at low diming level through mobile video mode or even better through slow motion video mode.

8.2.4 *Dimming Options*

As different Art and artist have varied requirement of lighting levels, dimmable luminaires with appropriate controls protocol is mandatory in Museums & Galleries.

Currently, the widely available dimming options are Phase Dimming (1% to 100% flicker free dimming) and DALI (Digital Addressable Lighting Interface) (0.1% to 100% flicker free dimming) protocol. The on board Phase Dim integrated within luminaire is Simple, convenient, economical and quick on site dimming option. However, recent introduction of wireless dimming with BLE (Bluetooth Low energy) or Zigbee technology is already being adapted by hi-tech and futuristic Museum sites.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft NATIONAL LIGHTING CODE OF INDIA

PART 5 INTERIOR ILLUMINATION

Section 8 Lighting for Residential Area

[First Revision of SP 72 (Part 5/Section 8)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49 **Last Date for Comments: 06-June-2024**

FOREWORD

The purpose of residential lighting is to set the scene for comfort and protection in residential spaces and other areas intended to impart a residential atmosphere.

Lighting design of residential spaces is less rigid than other spaces, with each new residential project requiring a fresh perspective while designing. Residential spaces encompass the most detailed aspects of lighting design due to the occupants' emotional, intellectual and personal involvement with the project. The different activities and tasks within the same residential space may require different lighting conditions, and certain activities can be visually quite demanding. Factors such as occupants' age and different times of use impact majorly on the lighting design of residential spaces. The lighting solution should be suitable to all potential usage patterns of the space while addressing the owners' preferences and conveying the owners' personality.

A residence is both the owners' private space and a venue for entertaining relatives and friends. Spaces for multipurpose as well as dedicated-use are now being designed in residential projects that provide, at the most personal level, a unique space for refuge, safety and family activities. Appropriate lighting techniques are required to address these uses, accommodating everyday likes and dislikes and fulfilling everyday wishes to give the owner a better living environment. Consequently, such projects may take longer than anticipated whenever the owner must connect with and approve of every detail.

This document indicates best practice for lighting; that is, utilising efficient light sources with effective controls to provide a suitable standard of illumination and a pleasant ambience for residents.

1 SCOPE

This part and section of the code covers the principles and practice governing good lighting for various residential premises. It recommends the quality and quantity of lighting requirements to be achieved in residential spaces.

2 TERMINOLOGY

For the purpose of this standard the definitions given in Part 1 of this code and those given in the IES Lighting Handbook and SLL Lighting Handbook (Glossary of terms) shall apply.

3 NORMATIVE REFERENCES

Following *International* guides, handbooks and standards referred in this part and section are necessary adjunct to this standard:

International Standard	*Title*
ANSI/IES RP-11-17	IES Recommended Practice for Interior and Exterior Residential Lighting Environments
LG9	Lighting Guide 9: Lighting for communal residential buildings
	IES The Lighting Handbook 2016
	SLL Lighting Handbook 2018

4 QUALITY OF LIGHT

Quality interior spaces demand thoughtful attention to various lighting components such as colour, direction, and intensity variations, which create different “layers” of light. Varying the properties of these layers can create the most appealing and versatile spaces. The overall feeling thus produced by the different lighting layers in a space can be characterised by descriptions such as bright, cold, energizing, relaxing, soft or warm. To further develop this layering effect, a focussed direct light source can be used to provide visual cues for leading the eye in a space such as highlighting art pieces, flora arrangements, textiles, etc. A layered lighting scheme that lends itself to the selection of these different descriptions or “scenes” within the same space is thus considered well designed.

4.1 Colours and Finishes

The different colours and finishes of room surfaces impact the quality of the luminous environment significantly, as they reflect light in different ways. Reflectance is the measure of the proportion of light reflected off a surface, and it has two aspects. The first aspect is the *reflectance value*, which describes the percentage of light reflected from the surface instead of being absorbed. Light-coloured materials have a higher reflectance, reflecting more light and absorbing less light (and heat), than dark-coloured materials. High-reflectance room surfaces appear brighter and are necessary in spaces with daylight, especially on ceilings and window walls to reduce contrast and glare. The second aspect is the range from shiny to matte, or *specular* to *diffuse* surfaces. Specular surfaces do not necessarily reflect more light than diffuse surfaces; they simply reflect light in a different manner. Specular surfaces can create delightful glints that can be desirable in some spaces but specular reflections can sometimes be distracting, annoying or even dangerous. Diffuse surfaces create a softer appearance and contribute to a more uniform illumination making the room appear brighter. As the efficacy of lighting is influenced by the décor (reflectance of the walls, ceiling and floor), lighting should be selected in conjunction with (and not before) the decorative scheme.

4.2 Flattering Effects

Savvy homeowners desire flattering effects through lighting. Indirect lighting can be very flattering when its diffuse properties are presented with warm colour temperature light sources (2500K to 3000K) and dimming controls.

4.3 Visual Impressions

Visual impressions of a space such as public vs. private, pleasant vs. unpleasant, small vs. spacious are obtained from an initial viewing of that space. Meeting the occupants' innate need to quickly assess their surroundings is the primary goal of good lighting. Dingy lighting with a lack of peripheral luminance will be perceived as unpleasant leading to feelings of hesitation and uncertainty. On the contrary, lighting that effortlessly leads the eye to all the focal attractions in the space will be perceived as pleasant. A layered lighting scheme with various circuited zones under lighting controls can help create different ambiences within the same space. Bright uniform lighting via sparkling chandeliers, wall scones and bright cove lighting can suggest a celebratory public event while the same luminaires dimmed to 25%, 50% and 75% brightness respectively can suggest a formal private event. A large space can be made appear smaller with more focussed lighting placed at human scale for certain occasions while the original scale can enhanced by highlighting the high ceilings and walls on other occasions. Different colour temperatures of light can be mixed together to provide subtle variations in the space thereby adding to the visual interest. Programmable lighting controls enable the recreation of the desired scenes over and over again based on the occupants' requirements.

5. QUANTITY OF LIGHT & DESIGN IDEAS

Quantity of light is evaluated in terms of illuminance – the density of light or lumens incident on a surface. Illuminance is measured in lux or lumens per square metre. However, as the incident light is not visible, occupants cannot see "lux." Occupants can only see luminance – light that is reflected from an opaque surface, or transmitted through a translucent or transparent surface. Luminance is measured in

candelas per square metre. Common tasks performed in residential spaces have evolved and changed over time so have the furniture layouts and design expectations. Reading and writing with pens and papers have given way to e-books, smartphones and tablets. Technology enables occupants to be flexible in when and where they work or engage in leisure activities within the home.

5.1 Entrances (200 lux)

Entrances give occupants and visitors their first impression of the building with lighting as one of the key factors in creating that impression. Entrances should be adequately lit to provide an attractive and welcoming space, but it also creates a feeling of security, especially for occupants returning alone late at night.

5.2 Corridors (100 lux; Night time: 20 lux)

Corridors are generally designed without windows hence tend to have little or no natural light. Consequently, electric lighting is more likely to be in constant use. Height and width along with luminaire spacing are important determinants to ensure adequate illumination and visual interest is maintained throughout the entire length of the corridor.

5.3 Stairs (100 lux on the Treads)

Stairs should be well illuminated for safety reasons, given the possibility of serious injury if someone falls. The treads along with the top and bottom step of each section of the stair must be clearly lit to show where the stairs begin and end. A low level of lighting should be provided whenever daylight is insufficient, with manual or automatic control for full illumination at appropriate times. Glare is a major hazard on stairs so light fittings with suitable diffusers and a luminance no greater than 300 cd/m2 should be selected.

5.4 Bathrooms (150 lux) and Toilets (100 lux)

Bathrooms and toilets illumination should be guided by both aesthetics and durability. Waterproof luminaires (IP44 or better, e.g. IP54, IP65) are required near wet areas such as baths and showers. At least two luminaires, a main light on the ceiling or wall, and a light over the mirror with separate switches should be provided to allow residents to switch on the main light on entry and add the mirror light if required. An additional nightlight providing continuous illuminance of 20–30 lux should be provided for elderly residents.

5.5 Bedrooms (100 lux)

Bedrooms being the residents' core private space require careful consideration in terms of lighting. Many daytime hours may be spent here, carrying out a variety of visual tasks such as reading, writing, working at a computer, bed-making, cleaning, using cupboards and medical examinations, etc. Therefore lighting

should be decorative rather than utilitarian with general illumination from one (or more) main light and additional task lights at the desk and bed for reading.

5.6 Lounges (100 lux)

Lounges benefit greatly from the interest and flexibility provided by a layered lighting approach. At least two lighting types with separate switches should be combined for residents to select between two lighting levels. Lounge lighting is more effective if it takes into account the anticipated colour and style of decor and furniture.

5.7 Lift lobbies (100 lux)

Lift lobbies require uniform horizontal and vertical illumination for the safety and security of residents. For lobbies requiring electric light at all times it is advisable to install more than one luminaire to ensure there is still some illumination in case one fails.

5.8 Kitchen (200 lux) and Dining (150 lux)

Kitchen requires low-glare uniform illumination best provided by ceiling luminaires enclosed with glass or polycarbonate covers, which can be easily removed for cleaning. Dining areas are distinct from the kitchen and the lighting should reflect this, as well as being switched separately from the kitchen area. Decorative lighting on walls or ceiling, such as wall brackets or pendants, creates a pleasant atmosphere.

5.9 Utility rooms (200 lux)

Utility rooms require good, uniform, low-glare lighting, which can be provided by ceiling or wall luminaires; downlights alone are not recommended because they provide little light on walls, ceilings and vertical surfaces.

5.10 Exterior (10 lux)

Exterior lighting should ensure basic safety and security for residents during hours of darkness, mark the access route to entrance, while creating a pleasant environment around the buildings as well as identifying a specific building after dark. As elderly people adjust slowly to substantial changes in illuminance, the transition zone between interior and exterior must be considered, e.g. providing 50 lux just outside the main entrance and tapering to 20 lux on the path or car park.

6 LIGHT SOURCES

Light sources being the key light-producing component of the lighting system should be carefully selected during the design process. However, it is important to note that certain light sources are better suited for certain applications.

6.1 Daylight

Daylight has been the primary source of illumination throughout human history; it is the use of diffuse light from the sky rather than the direct light from the sun for illuminating interior spaces. The aesthetics of the space is enhanced by the variability of daylight while providing a connection with the outside, thereby improving occupant satisfaction. Daylight should be used in combination with electric light for illuminating interior spaces, as they are compatible and complementary.

6.2 Incandescent Light Sources

Incandescent light sources produce light by heating a tungsten filament until it glows, and are available in various shapes and sizes. There are two further variants within incandescent light sources namely tungsten-halogen and low-voltage versions. Tungsten-halogen light sources are designed to redeposit the vaporised tungsten onto the filament resulting in a whiter light with little lumen depreciation than conventional incandescent light sources. Low-voltage incandescent and tungsten-halogen light sources provide the benefit of relatively compact size and highly precise beam control compared to line-voltage sources owing to their smaller filament size. This enables precise beam control and pin-spot illumination of small objects with additional feature of built-in reflector sources. While incandescent light sources can be dimmed, the transformer used for low-voltage light sources should be rated for dimming.

6.3 Fluorescent Light Sources

Fluorescent light sources produce light by passing current through a gaseous discharge by relying on ballast to provide start-up voltage and regulation of current during operation. The compact and linear fluorescent light sources are available in various shapes and sizes. Linear fluorescent light sources are generally used in utility spaces in residences such as garages, kitchens or workshops for under-cabinet lighting of working counters or wall-slots. Compact fluorescent light sources (CFLs) with integral ballasts are generally used as direct replacement for incandescent lamps to provide cooler soft illumination with other advantages such as less glare and longer service life. However due to higher content of gaseous mercury fluorescent light sources are generally not an “environmentally friendly” option.

6.4 Light-Emitting Diode (LED) Light Sources

Light-emitting diode light sources consist of solid-state devices that convert electrical current directly into light. Individual LED light sources are available in single-coloured red (R), green (G) and blue (B) arrays, RGB arrays for colour mixing and phosphor-coated arrays for a variety of whites (2700K-6500K). LEDs are available for a variety of residential applications such as accent, cove, task and under-cabinet lighting; downlighting; landscape, spa and pool lighting; and special effects lighting.

6.5 Cold Cathode Light Sources

Cold cathode light sources also produce light by passing current through a gaseous discharge by relying on high voltage. They can be custom-made to the exact length and shape required for accentuating a building detail.

7 LIGHTING DESIGN TECHNIQUES – BASIC

A layered lighting design scheme requires judicious selection as too many light sources can make a space appear visually busy and cluttered. The patterns of lighting within a space should make design sense without adding to unnecessary costs. The selection of light sources and luminaires is also critical as decorative luminaires can be visible, while other luminaires can be discreetly integrated into the architecture. Some luminaires can provide more than one layering function such as a chandelier with a downlight component, which can play multiple roles of ambient, decorative as well as focussed illumination.

7.1 Task Lighting

Task lighting is a fundamental component of a layered lighting design scheme as it provides the minimum illuminance required for accurately and safely performing visual tasks at the desired speed. Many decorative and surface-mounted luminaires such as floor lights, portable table lights and under-cabinet lighting can provide task lighting for residential spaces. Portable lighting provides the flexibility for changing the lighting positions to match the changing task positions. However, special care should be taken to avoid discomfort glare as task lighting may be close to the occupant.

7.2 Downlighting

Downlights' (ceiling recessed or surface-mounted) spacing should be organised in line with the architecture of the space. The beam spread of downlights generally becomes narrower with the mounting height. Careful placement of downlights with respect to walls is necessary because placing them too close to a wall may result in unattractive tall thin highlights known as "scallops." Strong downlighting should be avoided in spaces frequented for social communication as this can produce unflattering deep shadowing of facial features.

7.3 Vertical Lighting

Vertical lighting of surfaces such as walls, columns, etc. can increase the perception of brightness by articulating texture and utilizing reflection of these surfaces, thereby making room appear more spacious. The techniques used in vertical lighting include wall-washing and wall-grazing.

7.3.1 *Wall-Washing*

Wall-washing is the even smooth graded wash of light from top to bottom with a uniform distribution of illuminance across the entire wall. Wall-washing is advantageous for hiding imperfections in wall surfaces as it eliminates shadows thereby flattening the wall's visual appearance. Luminaire quality and placement are critical for achieving an even washing effect. The common rules of thumb for luminaire placement to achieve an even wall-washing effect include:

a) Luminaires to be placed one-fourth the distance of the wall-height from the wall;

b) Luminaires to be placed on a line projected at 30 degrees from the wall and starting at its desired focal point;
c) Luminaires centre-to-centre spacing to match their distance from the wall.

7.3.2 *Wall-Grazing*

Wall-grazing is a more dramatic manner of heightening shadows and revealing textures by reducing the angle of light striking the wall. Luminaires are placed closer to the wall depending upon the type of desired grazing effect. For grazing an entire wall, the luminaire should have a 1:1 ratio between centre-to-centre spacing and distance from the wall. However, appropriate luminaire positioning should be decided after a mock-up with the luminaires and materials.

7.4 Accent Lighting

Accent lighting is used for attracting attention to a particular area or highlighting artefacts such as floral arrangements, furniture, paintings, sculptures, etc. The highlighting effect is achieved through luminance contrast where the selected area or object is brighter than its surroundings. In case the objects of highlight are likely to be moved, it is always advisable to select flexible luminaires that can be re-aimed. The selected light sources or luminaires should also enable beam distributions from pin-spot for very tight focus on small objects to wide beam for defined focus on particular areas in a space. The common rule of thumb to achieve accent lighting yet avoid excessive luminance that may cause visual fatigue includes:

a) Accent luminance should be at least three times higher than ambient luminance.

7.5 Indirect Lighting

Indirect lighting is generally produced by light reflected off surfaces with suitable reflectance and colour to produce soft ambient illumination. Luminaires with an uplight component with the ceiling or wall essentially functioning as reflectors generally considered part of the indirect lighting system. Indirect lighting works on the brightness of the room surfaces by making the space appear look brighter and more spacious.

7.6 Cove Lighting

Cove lighting utilises concealed light sources within perimeter coves that provide soft indirect lighting of spaces by creating pleasant patterns in the ceiling. While linear light sources are the most economical option for cove lighting, care should be taken to create a seamless pattern by avoiding socket shadowing between the light sources.

8 LIGHTING DESIGN TECHNIQUES – VISUAL TASKS

A layered lighting design scheme also requires appropriate illumination for the visual tasks at hand. Visual tasks are unlimited in number, but can be classified according to certain common characteristics. Classification is made according to the prime and fundamental visual task characteristics along with their appropriate lighting techniques for good visual perception.

8.1 Mirrors

Mirrors are used for detailed tasks such as applying makeup, arranging hair or shaving which requires soft light to fall on the face, head and neck. Open or direct luminaires placed over the persons' head can cause shadows and glare. More than one luminaires is advised for supplying light to the face, hair and neck. Well-distributed diffuse light is preferred from side-mounted luminaires, mounted outside the cone (60 degrees) of vision.

8.2 Computer Desk

Computer desks are used for various tasks including reading paper-based information, typing on matte or glossy materials and writing on paper. It is important that the eye does not receive any direct glare or any reflected glare from any adjacent specular surfaces or materials. Multiple luminaires in the space may help balance the luminance ratios. Any portable luminaires must be places on the opposite side of the writing hand to avoid hand shadows. Ambient light is also recommended to keep the task-to-ambient contrast ratios from becoming too extreme.

8.3 Bed Reading

Bedside reading luminaires should illuminate the reading material with the reader seated or in a semi-reclining position. Adjustable luminaires are preferred with the provision of well-shielded directional light. A subtle balance of task and low-level ambient illumination is advisable to prevent eyestrain.

8.4 Kitchen

Kitchens require dedicated lighting for tasks performed on countertops such as cutting, measuring, reading, etc. apart from ambient general illumination. Linear task lighting under the cabinets will provide soft glare-free illumination for countertops as well as backsplash area. Cabinetry millwork should shield any direct views of the luminaires. Kitchen sinks should have ceiling luminaires mounted either directly above the sink or on each side of the sink angled in towards the centre of the sink. Luminaires should not be located directly above the users' head as this will lead to distracting shadows on the sink.

8.5 Dining

Dining table lighting should create a varied ambience for various tasks such as eating, preparing, inspecting and reading about food along with enhancing the colour of food and adding sparkle to glassware, silverware and dishes. While open direct lighting will enhance appearances the best and create sparkle, this should not be provided directly over the heads of people seated at the table. The colour of light should be complementary to the dining areas' finishes.

8.6 Stairs

Stair lighting should be designed in concert with the adjacent landings and vertical surfaces, so that the entire transition is experienced as a whole. Illumination of the treads and risers is as important as the vertical illumination of the landing. Special consideration should be given to the senior citizens as well as the differently abled individuals.

9 LIGHTING EQUIPMENT AND APPLICATIONS

Lighting equipment in a layered lighting design scheme may range from the decorative (chandeliers, scones, etc.) to the more functional (downlights, spotlights, etc.) luminaires. The three main criteria for luminaire selection and specification in residential lighting include:

a) Luminaire application – ease of installation and maintenance, economics, functionality and structural suitability
b) Luminaire performance – light distribution, output and pattern
c) Decorative considerations – light quality along with finishes and styling

9.1 Recessed Luminaires

Recessed luminaires are inconspicuous luminaires usually installed in the ceiling. The light source is regressed above the ceiling plane to distribute light downward or angled in a direct distribution pattern while reducing direct discomfort glare. Adding optical components such as reflectors, lenses, louvers or diffusers can create a variety of light distribution patterns. Recessed luminaires are generally used for accent lighting, general lighting, task lighting and wall washing. Decorative considerations include colours of reflectors and trims along with size of apertures e.g. trims could match the ceiling finishes and typically smaller size apertures are more suitable for residential spaces. Recessed luminaires can be mixed with other luminaires to add functionally and aesthetic appeal in a layered lighting scheme.

9.2 Surface-mounted Ceiling Luminaires

Surface-mounted ceiling luminaires find application in larger general-use (e.g. kitchens) and smaller special-use (e.g. closets) areas hosting a wide variety of tasks and requiring higher illuminance levels.

9.3 Track-mounted Luminaires

Track-mounted luminaires permit maximum amount of flexibility where the tracks can be configured in many directions and the attached luminaires can be aimed in different directions.

9.4 Suspended Luminaires

Suspended luminaires can be both decorative and functions, providing concentrated direct illumination or ambient general illumination. Chandeliers are hanging decorative sculptures with exposed light sources that add design elements and lighting effects to a room. Pendants with open bottoms hung at or below eye-level add a decorative luminous element to a room while effectively illuminating the surface below.

9.5 Under-Cabinet Luminaires

Under-cabinet luminaires are predominantly linear or individual “puck” luminaires positioned strategically to produce minimal reflected glare off surfaces. They usually provide accent, decorative or task illumination and are not the main source of ambient general illumination. Task luminaires are used in larger task areas such as kitchen counters to evenly illuminate the counter space. Accent luminaires are deployed in confined spaces such as bookshelves and display cases. Most luminaires are fitted into the surrounding architecture and should be considered an integral part of the layered lighting scheme.

9.6 Wall-Mounted Luminaires

Wall-mounted luminaires are predominantly used for decorative accents such as wall scones, task illumination such as vanity luminaires or exterior general illumination such as wall brackets. They should be selected based on illuminance output, light distribution and decorative quality. Wall brackets and scones generally placed at eye level should minimise direct glare by using low-wattage light sources, less-transmissive diffusers and better light source shielding. For exterior applications, these luminaires should be easy to relight, suitably rugged for use in high-traffic areas, resistant to insects and water.

9.7 Portable Luminaires

Portable luminaires should be chosen for their decorative suitability, amount and quality of light delivered for the desired tasks, and the ambient light provided for the general illumination. The product categories within the portable luminaires include table lights, floor lights, task lights and torchieres. Table lights should be appropriately styled to work well with other room furnishings. Floor lights generally are taller versions of table lights and share the same selection considerations. Task lights are small shaded luminaires that provide myriad forms of flexibility. Torchieres provide indirect soft general illuminance either by sending all the light to the ceiling that is redirected back to the room or by being luminous forms.

9.8 Integrated Luminaires

Integrated luminaires are generally seamlessly integrated with the architecture to provide some of the most architecturally enhancing and stimulating effects.

10 LIGHTING CONTROLS

Lighting controls can make all the difference in a meaningfully layered residential lighting design scheme. Even before the use to electric light, lighting controls in residences encompassed the use of curtains and shades to control the amount of natural light. The advent of electric lighting led to switches and eventually solid-state dimmers, which allow homeowners to tailor the amount of light in their residences. However, the functions of a residence have transformed drastically where home automation systems have put the tools of the facility manager into the hands of the homeowner. Single user interfaces popularly know as “connected lighting” can now be used to control air-conditioning, lighting, security, shade and sound systems.

Precise information about the architecture, budget and lifestyle involved in the residential design will further help steer the design of lighting controls in the appropriate direction. As there is no “one-size-fits-all” solution in lighting controls, anything from simple wall switches to cloud-based systems operated with smart devices may be suitable for a given project. Control technologies with numerous different cost, feasibility and flexibility features are now available in the market. The size and nature of the project will help identify appropriate lighting control technologies as some technologies are limited by the number of control points allowed or the size of the project. It is important to know the expressed or implied budget of the project before specifying the lighting control system to make clients understand its value added benefits. Clients’ expectations and lifestyles must also be understood to specify lighting control systems with matching capabilities.

10.1 Control Methods

Control methods used for varying the properties of a layered lighting design scheme include dimming control, preset scene control and automated control.

10.1.1 *Dimming Control*

Dimming control methods such as phase-cut, 0-10V analogue, digitally addressable lighting interface (DALI) or digital matrix (DMX512) should be established before hand for a smooth flicker-free dimming. Phase-cut dimming interrupts the sine wave of an alternating current (AC) supply, where forward phase-cut works well for incandescent luminaires and reverse phase-cut works well for low-voltage drivers and transformers. 0-10V Analogue dimming supplies a low-voltage signal to ballasts and drivers, and is more suitable for fluorescent and LED luminaires. DALI and DMX512 assign unique address to each luminaire and are more suitable for controlling multi-channel colour tunable luminaires and theatrical applications.

10.1.2 *Preset Scene Control*

Preset scene control is used to group and dim multiple layers of lighting into a set of scenes that can be recalled whenever required by the homeowner. They typically consist of one master control station per room, and up to 16 auxiliary control stations.

10.1.3 *Automated Control*

Automated controls include timer/photocell and occupancy sensors. Timer/Photocell can be used to automatically turn the lighting on or off depending upon time or available daylight. Occupancy sensor can be used to detect body heat or motion in a space, and automatically turn the lighting on, and after a period of inactivity can turn the lighting off.

10.2 Control Interfaces

Control interfaces can be both wired interfaces mounted on the wall or wireless interfaces.

10.2.1 *Wall Interfaces*

Wall interfaces are typically toggle/rocker switches, dimmer switches or preset scene interfaces. Toggle/Rocker switches provide simple on/off control for single zones. Dimmer switches provide on/off control and full-range dimming capability for single zones. Preset scene control interfaces can have multiple options of providing on/off control, full-range dimming and preset scenes for multiple zones.

10.2.2 *Wireless Interfaces*

Wireless interfaces can create bridges of communication without physical wiring where each device has a unique address and can be remotely accessed by other devices in the network or via a master control station. The most common protocols that support wireless communication are Bluetooth, Radio Frequency (RF), ZigBee Light Link (ZLL) and ZigBee Home Automations (ZHA).

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PART 5 INTERIOR ILLUMINATION

Section 9 Lighting for Places of Worship

[First Revision of SP 72 (Part 5/Section 9)]

Illumination Engineering and Luminaries Sectional Committee, ETD 49 **Last Date for Comments: 06-June-2024**

FOREWORD

Lighting holds profound significance in places of worship, influencing the ambiance and spiritual experience of visitors. Beyond its practical function of illuminating sacred texts and architectural details, lighting sets the tone for contemplation, prayer, and communal gatherings. Thoughtfully designed lighting can enhance the architectural beauty of the space, highlighting symbolic elements such as altars, statues, and stained glass windows. It can evoke a sense of reverence and awe, fostering a connection to the divine and enhancing the overall spiritual journey.

1 SCOPE

The scope of this section is to encompass lighting parameters and guidelines for the various types of places of worship commonly found in villages, towns, and cities across India. A place of worship is defined as a building or a specific room within a building where people gather for prayer and activities associated with their faith.

The lighting design for places of worship recognizes the diverse sizes and designs inherent in various religions. The approach involves individual consideration for each religion or its variant, addressing specific lighting challenges posed by religious activities or building layouts.

2 FUNCTIONS OF LIGHTING IN PLACES OF WORSHIP

Lighting has following objectives in places of worship:

a) to enable participants in the religious activity or ceremony to see what they are doing
b) to enable the congregation or assembly to see what is happening around them
c) to contribute to the safety of everyone within the room or building and
d) to create a good visual environment.

3 LIGHTING CONSIDERATIONS AND PARAMETERS

Lighting for places of worship should be guided by several key criteria that consider the architecture while also being sensitive to the nature of worship within the building. This sensitivity is especially crucial in cases where light holds symbolic significance for that religion.

lighting in such buildings is often required to complement the interior while also highlighting particular religious objects. Attention must be paid to details such as energy consumption, carbon emissions and maintenance requirements during the lighting projects. Daylighting may also affect the lighting design and should be used when possible.

Lighting applications for the main worship areas of temples, churches, synagogues, Gurudwaras and mosques is for various functions and may be architectural lighting design. The congregation areas need adequate General lighting varying from 200 to 500 Lux.

It is common in places of worship for tasks to occur on different planes, horizontal, vertical and anywhere in between. The illuminance recommendations given are to be produced on the plane in which the task lies.

In main worship areas, such as temples where the idol is located, accent lighting should be three times higher but focused on the vertical plane. Higher levels are also suitable for areas intended for television cameras. Similarly, other religions have focal points that require special treatment, such as the Koran in a mosque or the Scriptures in a synagogue.

Architectural lighting should be kept at 25% or less of the lighting level in seating or congregation areas. Indirect or architectural lights are employed to accentuate architectural elements like ornamental plasterwork, wall stenciling or ritual script features. Additionally, architectural lighting can highlight ceiling columns and walls, enhancing their ornate features and bringing attention to arches or trusses. Illuminating walls and overhead surfaces can significantly improve the overall appearance of the room or building.

4 ARCHITECTURAL OBSTRUCTIONS AND SOLUTIONS

Many religious buildings feature obstructions like stone pillars, cross beams and banners that hinder light distribution. Addressing potential shadowing issues from these obstructions requires special design considerations with various approaches available to mitigate the problems caused by them.

a) If obstructions like overhead cross beams are present, consider positioning the lighting below the obstruction to mitigate shadowing.
b) In areas with minimal obstructions, such as large stone pillars, it's essential to ensure uniform illumination by employing at least two luminaires per area. These may include roof-mounted

fixtures or floodlights positioned on walls or pillars. Combined with high indoor surface reflectance, this approach helps eliminate areas with insufficient illuminance.

5 LIGHT SOURCES AND LUMINAIRES

Projects of this nature typically demand a variety of luminaires with different optics, reflectors, or specialized technical capabilities to achieve the desired lighting effects. For instance, narrow beams of light can effectively highlight small objects such as statues or icons, while wall washers are essential for illuminating vertical elements. Additionally, spots with articulated mountings prove ideal for both direct and indirect lighting of frames typically situated along the sides of hallways.

In most places of worship, which often encompass large areas, it's advisable to use a "warm" light source with a color temperature of 3000 K or 4000 K and a Color Rendering Index (CRI) of Ra>80. However, if the interior features marble, a color temperature of 5700 K might be more appropriate. For interiors with yellow stone, a 3000 K light source can enhance the space, with a CRI of Ra>80 in both cases. Additionally, in many religious buildings, lamp color is chosen for its overall effect rather than critical reasons.

In areas where precise color highlighting is essential, it is recommended to use light sources with a Color Rendering Index (CRI) greater than Ra90.

The choice of luminaire depends heavily on the building's structure. For instance, a large space with lower ceilings above the seating area may require recessed downlights. Conversely, a high ceiling in a temple, Gothic church, or gurudwara would be best illuminated with suspended decorative luminaires above the standing or seating areas.

Choose LED luminaires due to their high efficiency and long lifespan, especially considering that many luminaires will likely be installed in hard-to-reach locations. Accent luminaires, such as track lighting with spots or downlights, can effectively highlight religious objects, speakers, or other points of interest. Incorporate architectural lighting to complement general ceiling lighting and for wall washing, enhancing ornate features and highlighting architectural elements like arches or trusses. Strategically placed indirect LED floodlights or spotlights can be particularly effective in achieving these lighting goals.

6 CONTROL

Modern religious buildings serve a vastly expanded range of purposes, hosting various events throughout the day. These can include ceremonial or religious events, weddings, concerts, theatrical presentations, and of course, traditional religious activities.

Temples, gurudwaras, churches, shrines, mosques, and other places of worship experience significant variations in occupancy. The main assembly areas might see high occupancy for only a few hours a week, such as on Fridays in mosques, Sundays in churches, or during festivals like Navratri, Ganpati, or Durga Puja in Hindu temples, and on Buddha Jayanti and Mahavir Jayanti in Buddhist and Jain temples. Additionally, there may be occasional but significant use during the week for group meetings, weddings, prayers for the departed soul in gurudwaras, and funerals in churches.

Larger and better-known places also have to cater for the requirements of tourist visitors, as well as their own liturgical functions.

To accommodate the varying activities, a centralized, automated preset control system is essential. This system can adjust the lighting scene to suit specific activities. However, it's important that scene shifts are gradual and unobtrusive, often requiring dimming capabilities. Therefore, the selection of LED luminaires and driver types must carefully match the chosen control system. These controls provide the flexibility to change the appearance of the worship space as needed.

Such lighting may also encompass the exterior of the building, either to display the architecture at night or to ensure safe passage to and from car parks etc. Again, attention must be paid to issues such as energy efficiency and maintenance requirements while also avoiding light spillage and light pollution.

7 LIGHTING OF HERRITAGE BUILDINGS

Many religious buildings will be of architectural or historical interest and may be under Archaeological Department of India or they are under the control of the Trust. In both the cases the permission is needed to carry out the lighting work for which detailed plan and method of work is to be submitted. This is to mainly avoid the damage to the structure, carving, etc. If the architecture, inside or outside, is of stones – marble, Granite, red/pink/grey stone, and invariably with beautiful carving, pattern on ceiling, floor, wall etc. and therefore re-doing the similar matching in terms of material and workmanship is practically impossible when damaged.

The existing Luminaires may have aesthetic heritage value and provide an ambience that relates to the original intended design and appearance. Opportunities may also exist to introduce additional types of light to highlight or reduce the dominance of particular architectural or liturgical features, define spaces, enhance colours, textures and forms in addition to their functional necessity.

7.1 Existing luminaires — Efforts should be made to retain and incorporate existing lighting fixtures, such as pendants, chandeliers, sconces, or any other types, into any new lighting systems. Before removal for restoration, all existing and significant lights should be inventoried in situ. Each existing light should be carefully examined to ensure compliance with current regulations and safety standards. They may require cleaning, polishing, lacquering, repair, rewiring, and, if necessary, specific parts replacement or alteration to meet current regulatory requirements.

7.2 New lighting system

7.2.1 *Interior*

The new lighting system should enhance the character and appearance of the place and the quality of the experience. Proposed lighting should not produce unnecessary glare. One discrete solution is to use carefully located up lighters and light the interior from the reflected light off the ceiling. This solution however requires very powerful lights and with LEDs it is possible. One of the simplest solutions is to use simple pendants and if these have light weight acrylic shades, perhaps cylinders, spheres or half spheres they can be suspended on the power cable alone avoiding additional wire suspensions.

7.2.2 *Exterior*

External floodlighting may assist to highlight important architectural features of the place of worship at night. They may also be required for security and safety reasons. Unobtrusive locations should be sought for spot and floodlighting and any luminaires to exterior fabric minimised.

8 EMERGENCY LIGHTING FOR PLACES OF WORSHIP

Proper emergency lighting is crucial for gathering spaces like places of worship, especially where there is deemed to be a risk to the safety, health, or welfare of staff and the public in the event of normal lighting failure requiring swift building evacuation. Whether it's in older or new buildings, with burning oil lamps or candles, and with hundreds of people gathered at once, fire prevention and safety are critical in temples, mosques, churches, gurudwaras, and other places of worship.

Emergency lighting equipment must be used on the following:

a) Existing places of assembly where at least 50 or more persons gather for deliberations, worship, entertainment, eating, etc.
b) The building is two or more stories in height above the level of exit discharge, i.e. grade level public way
c) The occupancy is subject to 300 or more total occupants

For the safety of people and property, following are fire and emergency tips:

a) Proper Exit Sign and "Nearest Exit" Plans with Maps
b) Emergency Lighting in case the power goes out
c) Smoke Detection and Carbon Monoxide Detection tested regularly
d) Sprinkler Systems and Fire Extinguishers in place
e) Fire Doors separating different floors or areas of your worship space
f) Staff training sessions to become familiar with emergency procedures